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The Impact Of Number Talks On Third-Grade Students' Number Sense Development And Mathematical Proficiency

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THE IMPACT OF NUMBER TALKS ON THIRD-GRADE STUDENTS' NUMBER SENSE DEVELOPMENT AND MATHEMATICAL PROFICIENCY

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ABSTRACT

This action research study employed a mixed-methods design to examine the impact of a number talks intervention on the number sense development and mathematical proficiency of students in one third-grade mathematics class. The number talks strategy was also studied to determine its impact on third-grade students' development of a productive mathematical disposition. Number sense is "a person's general understanding of numbers and operations along with the ability and inclination to use this understanding in flexible ways to make mathematical judgments and to develop useful strategies for handling numbers and operations" (McIntosh, Reys, & Reys, 1992, p. 3). This eight-week study involved conducting number talks in one third-grade class of 20 students for three days per week. The study followed the one-group pretest-posttest design to measure the effectiveness of this intervention. Quantitative data were collected using a teacher-created number sense assessment and the Number Sense and Operations instructional area of the mathematics Measures of Academic Progress [MAP] assessment. Qualitative data were collected using semi-structured group interviews. Quantitative findings showed that there were significant increases in the mean score of the teacher-created number sense assessment and the Number Sense and Operations MAP assessment. Qualitative results showed that students demonstrated a more productive disposition towards mathematics after the number talks intervention.

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CHAPTER 1: INTRODUCTION

Introduction

Number Sense

Many people view mathematics as facts, rules, and formulas. However, research shows that adults rarely use formally written computations and formulas (Wong, Ho, & Tang, 2017; Parsons & Bynner, 2005; McIntosh, Reys, & Reys, 1992). According to Boaler (2015), math facts are a small portion of mathematics, but they are best learned through using numbers in different ways and situations. This insight has led to an examination of how mathematics and computation are taught in the elementary classroom. How a person chooses to use mental calculations and computation strategies to solve problems is referred to as their number sense. "Number sense denotes an intuitive understanding of numbers, their magnitude, relationships, and how they are affected by operations" (Toll, Kroesbergen, & Van Luit, 2016, p. 431; Gersten, Jordan, & Flojo, 2005). Number sense is a "person's general understanding of numbers and operations along with the ability and inclination to use this knowledge in flexible ways to make mathematical judgments and to develop useful strategies for handling numbers and operations" (McIntosh, Reys, & Reys, 1992, p. 3). For example, when asked to solve the problem 6 x 8 someone with adequate number sense may have memorized the answer as 48, but they would also be able to work out that 5 x 8 is 40 and then add 8 to make 48. Number sense performance and growth are predictive of long-term mathematics achievement outcomes (Jordan & Dyson, 2014). Having adequate numeracy skills enable people to gain more education and better career prospects (Parsons & Bynner, 2005). When students develop number sense, they begin to possess many significant capabilities in mathematics, such as flexible mental computation, numerical estimation, and quantitative judgment (Greeno, 1991).

Mathematical Proficiency

The development of number sense is essential for a person to gain mathematical proficiency. Mathematical proficiency is required for adults to fully and productively participate in society and the economy (RAND Mathematics Study Panel & Ball, 2003). Obtaining mathematical knowledge is insufficient when the goal is to obtain success. Proficiency is being able to use that knowledge in appropriate circumstances (Schoenfeld, 2007). According to Parrish (2010), a mathematically proficient person possesses the ability to compute numbers accurately, efficiently, and flexibly. When a person can compute numbers accurately, they are able to produce an accurate answer. Computing with efficiency is the ability to use an appropriate and practical strategy to solve a problem. Computing flexibly means one is able to "use number relationships with ease in computation" (Parrish, 2010, p. 5). To exhibit these skills or abilities, a person may use flexible numerical computation by recognizing equivalences to regroup numbers in mental math, they may use numerical estimation by identifying approximate numerical values in calculations, and they may also use quantitative judgment and inferences by inferring about quantities and numerical values. For example, when faced with the problem 79 x 4, a person with the above-listed skills would see the relationship between 79 and 80. This person may compute 80 x 4 to get 320 and then subtract 4 to get 316. When students are able to make sense of problems like 79 x 4 they can use their understanding to solve more complex problems that may include more substantial numbers.

To complete mathematical computations accurately, efficiently, and flexibly students must understand the strategies they are choosing to use. As students use mathematical strategies they understand, they gain conceptual and procedural knowledge along with an increase in confidence (Chambers, 1996; Fuson et al., 1997). Huberty, Dresden, and Bak (1993) describe conceptual knowledge as how one perceives the links between various concepts. Procedural knowledge is the rules or procedures for solving mathematical problems (Hiebert & Lefevre, 1986). Both the respective roles of conceptual and procedural knowledge are vital in the learning of mathematics. Seigler (2003) explains that when students do not have number sense which affects their understanding of concepts and their ability to connect concepts to their procedures, they frequently develop systematic patterns of errors due to the successive generation of flawed procedures.

Mathematical Dispositions

When students continually struggle in math, they develop a negative disposition towards mathematics. The National Research Council (2001) refers to a productive disposition as "the tendency to see sense in mathematics, to perceive it as both useful and worthwhile, to believe that steady effort in learning mathematic pays off, and to see oneself as an effective learner and doer of mathematics" (p. 131). If students are to be successful and proficient in mathematics, they must believe that mathematics has the ability to be understood, with effort it can be learned and used, and that they are capable of figuring it out (National Research Council, 2001). A significant factor in determining students' educational success is their mathematics disposition. Students who view mathematical experiences and training as a way to expand their ability are more likely to seek and learn from challenging situations compared to students who view mathematical ability as fixed and are more likely to avoid challenges and become easily frustrated (National Research Council, 2001).

A teacher's instructional practices play a key role in students' mathematical disposition. When a teacher's instructional practices include allowing students comfort in doing mathematics and sharing their ideas with others, they see themselves as capable of understanding mathematics and thus maintain a more productive disposition towards mathematics (Cobb, Yackel, & Wood, 1993).

Number Talks

Many mathematics classes in elementary schools emphasize the unnecessary and damaging effects of rote memorization of math facts through repetition, practice, and timed testing (Boaler, 2015). Rote memorization is not a successful strategy because the memory of the human brain works by associating ideas, not numbers (Dehaene, 2011). The most successful instructional strategies help students to develop deep understanding by making connections between concepts and related procedures. This deep understanding is a part of number sense. This development of number sense is a critical foundation for high-level mathematics (Feikes & Schwingendorf, 2008; Boaler, 2015). When students develop number sense, they no longer have to rely on memorization but now have an understanding of algorithms used and can apply this knowledge and understanding to a variety of problems with varying levels of difficulty (Carpenter, Franke, Jacabs, Fennema, & Empson, 1998).

During this study, number talks were incorporated into the mathematics instruction to students to develop number sense and increase their mathematical proficiency while fostering a productive disposition about mathematics. During number talks, a mathematical problem is written on the board. Students are given thinking time and are expected to solve this problem mentally with as many different strategies as they can think of during the allotted time. Mental computations are used during number talks because it helps students to build on their understanding of numerical relationships as they are typically unable to use standard algorithms. During this time the instructor walks around the room and students demonstrate that they have solved the problem by holding up the number of finders that corresponds with the number of strategies they came up with to solve the problem. Research has shown that for students to remain persistent in their effort to develop mathematical sense they must feel that their contributions are valued (Campbell & Rowan, 1997). Therefore when the teacher sees that a majority of the students have solved the problem, students share their solutions. Both correct and incorrect answers are recorded on the board. Students are then given the opportunity to share and justify the strategies they used to solve the problem. At this time, the teacher takes on the role of facilitator and asks questions, prompts students, and helps students to correct misunderstandings. Number talks should incorporate various strategies and become increasingly harder.

Number talks are beneficial in assisting mathematics teachers in de-emphasizing rote memorization and focusing on developing critical-thinking and problem-solving (Boaler, 2015; National Governors Association Center for Best Practices & Council of Chief State School Officers, 2010). Classroom practices that include opportunities for students to acquire mathematical literacy teach students skills such as reasoning, problem-solving, and information analysis that will reap benefits in the classroom, employment, leadership positions, and social and economic advancement (Croom, 1997; Oakes, 1990).

In an effort to improve students' number sense, mathematical proficiency, and mathematical dispositions, the effect of implementing the number talks strategy with third-grade students was investigated. The aim of this action research study was to increase the effectiveness of my mathematics instruction by incorporating an instructional strategy that would assist my students in developing number sense, increase their mathematical proficiency, and gain a more productive disposition towards mathematics.

Statement of the Problem of Practice

The problem of practice that guided this action research study was students' lack of mathematical proficiency. The lack of mathematical proficiency has led to students' struggle to accurately solve math problems involving multi-digit numbers as well as multi-step and multi-operation problems. Students also struggled to solve basic math problems in efficient ways. For example, when faced with the problem 9 + 12, instead of adding 10 and 9 to get 19, then adding 2 to get 21, many students would start with 9 and count up 12. This strategy will lead students to the correct answer but becomes difficult to use as numbers become more substantial. A student who has reached mathematical proficiency comprehends mathematical concepts and can solve problems flexibly, efficiently, accurately, and appropriately. Because students have consistently struggled in math, they have also developed a negative disposition towards math and tend to avoid challenging math problems and become easily frustrated.

To gain mathematical proficiency, there are five components students must possess. These components include (1) conceptual understanding, (2) procedural fluency, (3) strategic competence, (4) adaptive reasoning, and (5) a productive disposition. Each of these components develops simultaneously while helping each other to develop. For example, as students build strategic competence their attitudes and beliefs about their math ability becomes more favorable. To better inform this research, my students' math homework, class assignments, classroom assessments, and standardized assessments were studied and analyzed. The majority of these students had difficulties understanding and recalling basic math concepts and facts. Research has shown that students have difficulty understanding complex mathematical concepts because they struggle with understanding and recalling basic math facts (Boychuk & Cui, 2014). Basic math facts are defined as a relatively small set of addition, subtraction, multiplication, and division questions (Boychuk & Cui, 2014). The lack of student proficiency in basic math facts often contributes to future difficulties in understanding and performing more complex multi-step mathematics problems. This lack of proficiency in basic math facts was shown to be a large contributing factor in my students' difficulties to use strategies to solve grade-level problems accurately.

Researchers such as Humphreys and Parker (2015) and Stott and Graves (2015) believe the cause of the current trend of students lacking mathematical understanding may be in how mathematics is taught. In many mathematics classes in the United States, the memorization of basic math facts is highly emphasized. Memorization is done through multiplication times table repetition, practice, and timed testing. Boaler (2015) found that the onset of timed testing is the beginning of math anxiety for about one-third of students. One study of MRI imaging on participants' brains found that the part of the brain where math facts are held, the working memory, became blocked and math facts became inaccessible due to anxiety and stress caused by completing timed math tests because cognitive processing is disrupted (Beilock, 2011; Boaler, 2015). Developing students' mathematical understanding should be the focus of instruction first, followed by fluency and automaticity (Boychuk & Cui, 2014; O'Connell & SanGiovanni, 2011). This organization of learning should be utilized because researchers have concluded that problems can still occur when students can recall basic math facts but are not able to understand or explain the concepts (Boychuk & Cui, 2014; Sparks, 2013). Students, often, demonstrate systematic patterns of errors when they cannot grasp or connect concepts and procedures. Teachers can help students to develop a mathematical understanding by incorporating an "instructional approach in which students investigate the meaning of facts through hands-on activities and thoughtful discussions, explore strategies to support their understanding of numbers, and then engage in strategic practice to memorize the facts" (O'Connell & SanGiovanni, 2011, p. 5). This type of mathematics instructional approach, which mirrors number talks, has shown to increase a person's general understanding of numbers and operations along with their ability to use this knowledge flexibly to develop useful and efficient strategies in a variety of numerical situations (Tsao & Lin, 2011). This is also known as number sense.

To develop number sense the mathematics class' instructional focus should be on developing critical-thinking, problem-solving, and analytical skills (Boaler, 2015; National Governors Association Center for Best Practices & Council of Chief State School Officers, 2010). One way to do this is to incorporate number talks into the mathematics class routine. Number talks are discussions held in small groups or as a class around computational problems that are solved mentally (Parrish, 2010). Number talks are designed to elicit strategies that focus on number relationships and number theory. They allow students to reason about numbers and build connections to key conceptual ideas in mathematics. During number talks, mathematical problems are expected to be solved accurately, efficiently, and flexibly.

The purpose of this action research study was to collect and analyze quantitative and qualitative data to investigate the impact number talks had on my third-grade mathematics students' number sense development, mathematical proficiency, and mathematical disposition. The results of this study are of interest to mathematics teachers who desire to increase students' conceptual understanding of numbers and their ability to work more flexibly and understand patterns within numbers.

Research Questions

The current research study examined the impact of an eight-week number talks intervention on third-grade students in one mathematics class. The following research questions guided the study:

1. *What is the impact of the number talks intervention on third-grade students' number sense development and mathematical proficiency?*
2. *What is the impact of the number talks intervention on third-grade students' dispositions towards mathematics?*

Purpose of the Study

The purpose of this action research study was to improve students' number sense and mathematical proficiency by incorporating number talks into the mathematics classroom routine. I also sought to investigate whether the addition of number talks into the math instruction would help my students to develop a more productive disposition towards mathematics. Research shows that number sense is important for students to learn as it combines learning math facts and a deep understanding of numbers and the ways they relate to each other (Boaler, 2015). People with number sense have the ability to use numbers flexibly to solve mathematical problems rather than relying on the memorization of facts. Alsawaie (2012), while conducting a study of sixth graders, found that students who relied heavily on school-taught rules confused and misused those rules in many cases. The goal for this study was to help her students develop number sense so that they would have a conceptual understanding of mathematics and that they could use this skill to be successful in completing higher level mathematics as required by the third-grade South Carolina curriculum standards. These learning objectives include multi-digit multiplication, multi-step equations using any of the four operations, and division. I also hypothesized that as students became more proficient in mathematics, they would develop a more productive disposition towards mathematics and have more confidence in their abilities. This goal was met by incorporating number talks into the classroom routine because number talks allowed me to change my learners' views of mathematics, teach them number sense, help them develop mental math skills, and engage them in creative, open mathematics (Stott & Graves, 2015). By doing this, my students gained a better conceptual understanding of mathematics and began to believe in their capabilities. This gained confidence caused students to work longer on challenging problems instead of giving up.

Methodology

The action research methodology was employed to evaluate the effectiveness of the number talks intervention on students' number sense in this third-grade class. Action research was implemented for this research study because action research is conducted for the purpose of solving a problem or obtaining information to inform local practice (Fraenkel, Wallen, & Hyun, 2015). The goal for this study was to determine if the number talks intervention would positively affect the students in my classroom community in their ability to solve math problems more efficiently, accurately, and effectively and to develop a more productive disposition towards mathematics. Action research is a systematic inquiry conducted by teachers to study their classroom, assessments, and practices to understand them better, improve their quality, and improve their effectiveness (Mertler, 2014). This action research study followed Mertler's (2014) recommended action research methodological cycle of planning, acting, developing, and reflecting to improve the effectiveness of my current mathematics instruction through the incorporation of number talks. This process involves identifying and gathering information on the topic of focus, collecting and analyzing data, developing an action plan based on the results of the study, and sharing and reflecting on the results.

A mixed-methods design, which includes both quantitative and qualitative data, was used to examine the research questions. A mixed-methods research design allowed for the exploration of the relationship between the number talks intervention and students' mathematical disposition (Fraenkel, Wallen, & Hyun, 2015). In collecting qualitative data through semi-structured group interviews, students were able to express their thoughts and feelings about mathematics directly. They were also able to clearly express how the integration of the number talks strategy affected their disposition towards mathematics. Mixed-methods research also allows for the clarification and explanation of any relationships found during the study, as well as helps confirm or cross-validate relationships (Fraenkel, Wallen, & Hyun, 2015). Okamoto (2015) found that implementing the mixed-method design was most helpful during his study in analyzing the impact of number talks inventions on sixth-grade students "number sense. Okamoto (2015) was able to collect quantitative data using a pre- and post-test, which allowed the data to show if students were able to answer the questions correctly, but did not provide information on the methods students used to solve the problem. The qualitative data that Okamoto (2015) collected was able to provide this information. My use of the mixed-methods design for this study followed this same structure. Quantitative data collected through the use of two different assessments were able to show whether students were able to accurately solve mathematical problems that tested a range of skills including numerical relationships. However, this is only a portion of evidence needed to show the development of number sense and mathematical proficiency. Also needed was data showing that students were able to solve problems efficiently and they possessed a productive disposition towards mathematics. Qualitative data that was collected through observing students' methods of solving problems and semi-structured group interviews were used to provide this information.

Quantitative data were collected during this study using the one-group pretest-posttest design. With this design, a pretest was given before the number talks intervention was implemented so that I would know if any change had taken place. The students were given two pretests. The first was a 10-question number sense classroom assessment. On this assessment, students were told to answer the questions as accurately as they could and to show their work. This assessment included questions using multiple operations on various levels and required the use of skills such as numerical reasoning and numerical relationships. The second pretest given was the Number Sense and Operations instructional area of the Measures of Academic Progress [MAP] assessment. This assessment measured students' number sense and mathematical proficiency. Questions on this assessment assessed skills in the area of place value, counting, base ten, and fractions (Northwest Evaluation Association, 2017). After the number talks intervention was implemented, these third-grade students were again assessed to determine if there were any changes in their number sense development or mathematical proficiency. Two posttests, which matched the pretests, were given and analyzed.

During the class number talks, Donald L. Chambers' (1996) three methods of computation were applied to identify the ways in which strategies were applied to solve mathematical problems. The three methods described by Donald L. Chambers (1996) include (a) direct-modeling strategies with manipulatives, (b) mental or written invented strategies, and (c) standard algorithms. More information was gathered on the impact of the number talks interventions on students' number sense development and their ability to work with numbers by collecting data regarding how students chose to solve mathematics problems. Collecting both quantitative and qualitative data allowed the teacher to obtain a complete picture of this action research study (Fraenkel, Wallen, and Hyun, 2015).

This action research study was conducted over an eight-week time span. Number sense develops gradually through exploration of numbers, visualization of numbers in a variety of contexts, and relating numbers in a variety of ways (Sood & Jitendra, 2007).

Therefore, the teacher dedicated three days per week during the eight-week time frame to conduct number talks during the mathematics class.

Significance of the Study

Many people believe mathematics is a set of rules and procedures to memorize that will later be implemented with speed and accuracy (Parrish, 2010). What is missing in this definition is the understanding of the relationships between numbers that are the foundation for the rules that must be applied. Without this understanding of numerical relationships, the ability to be successful in more difficult math courses is hindered. Using math in everyday life also becomes a challenge without number sense. Going through our daily lives, we must be able to check to make sure numbers make sense by building upon our foundational understanding of mathematics. Everyone does not have a special intuition that helps them to make sense of numbers and mathematics. High-achieving students use strategies to make computation easier, while low-achieving students do not interact with numbers flexibly, but tend to try to use memorization methods when conducting mathematical calculations (Boaler, 2015). This use of strategies, flexibility, and intuition with numbers that high-achieving students use is known as number sense (Dehaene, 2011). Research has shown that the acquisition of number sense may be linked to socio-economic status (Andrew & Sayers, 2015; Melhuish et al., 2008; Starkey, Klein, & Wakeley, 2004). Students who start school with poor number sense are likely to be low-achievers throughout their school career, without appropriate intervention (Andrews & Sayers, 2015; Aubrey, Dahl, & Godfrey, 2006). This frequently leads to tracking students into low-level mathematics classes. Tracking affects minorities and economically disadvantaged students negatively and lessons students' opportunities to learn and develop skills in higher-order thinking (Jones, 1993; Oakes, 1985; Oakes, 1986; Croom, 1997). Diversity within the classroom also affects students' ability in the mathematics class. Research has shown that a disproportionate number of students from underrepresented groups, such as minorities and females, drop out of mathematics (Croom, 1997). Students' language differences, cultural backgrounds, and socioeconomic status all affect how students perceive mathematics. Lucille Croom (1997) refers to this as their mathematical worldviews. Teachers should be aware of their students' diverse worldviews of mathematics to allow them to develop strategies to deal with these multiple perspectives effectively. (Croom, 1997). Not only does number sense play a major role in students' success, but their dispositions towards mathematics are also a factor in their educational success. When students feel negative about mathematics and their abilities, they avoid it. This avoidance can have an adverse effect on students into adulthood. As students get older and avoid challenging mathematics classes, they restrict their future job prospects such as in the medical and science fields (National Research Council, 2001). As their teacher, I want my students to gain success in school and reach their full potential. Therefore, I used this action research study to investigate an instructional strategy that I thought would help me build a positive culture in my classroom that all students felt valued and believed in their mathematics abilities. I aimed to do this by helping students develop number sense by increasing their understanding of mathematics concepts and using that understanding to build on their use of efficient, accurate, and flexible strategies. As students gain a better conceptual understanding, the other components of mathematical proficiency also develop and work together.

The results of this study will be of interest to educators and those who have a stake in education that seek to increase their students' ability and willingness to solve larger and more complex math problems than they currently are. This study addresses students who are unwilling to challenge themselves mathematically due to their past failures and growing frustration. This study also addresses what may be the cause of students' past failures and the most appropriate instructional strategies that may address these problems. Finally, this study addresses how the number talks instructional strategy can not only assist educators in building students' mathematics skills but also help to encourage students' development of a more productive disposition toward mathematics in which they believe that, with effort, they can understand and use mathematics. Through this action research study, educators will learn how to increase their students' success now and into adulthood.

Summary of the Findings

During this study, two research questions were addressed. The first research question was identifying the impact the number talks strategy had on third-grade students' number sense development and mathematical proficiency. To analyze students' math proficiency and ability to use their number sense to identify accurate and efficient strategies to problem solve, the teacher-created number sense assessment was used. The number sense assessment also allowed for the opportunity to investigate the specific strategies students used when solving math problems. The findings showed that the mean score for the students on the number sense assessment increased by 13.25 percentage points between the pretest and the posttest. On the posttest, students were also more frequently able to demonstrate the use of more efficient and effective strategies to solve problems than they were on the pretest. A total of 15 out of 20 students made gains on the number sense assessment after receiving eight weeks of number talks intervention.

The Numbers Sense and Operations instructional area of the MAP assessment was used to determine if students had made any gains towards their mathematical proficiency and if they were able to apply their number sense to problem-solve accurately. Ninety-five percent of students were able to demonstrate that they did increase in these areas. The mean score for the posttest for this assessment was 201.55. This is a 13 point gain compared to the pretest.

The second research question that guided this action research study was identifying the impact the number talks intervention had on my third-grade students' mathematical disposition. Data collected from the semi-structured group interviews revealed that students felt more confident in their mathematics abilities after participating in the eight-week number talks intervention and found the discussion of problem-solving strategies to be beneficial. The majority of students agreed they would like to continue the practice of number talks in their mathematics class.

To improve on this study, it is suggested that an explanatory mixed-method design is used to get a better understanding of students' conceptual understanding and gain insight into the significance of their number sense development. It is also suggested that formative assessments be administered at least every two weeks to gain knowledge of students' current progress and use that data to adapt the number talks to students' current needs.

Limitations of the Study

Although this study yielded beneficial results to my students and teaching practices, there were limitations to this research study. This study was based on the one-group pretest-posttest design. Therefore, there was no control group to compare the results to. The lack of control group possesses a limitation of the study because is it more difficult to determine if changes between pre and posttests were due to the intervention or an outside factor. A second limitation of this study was the sample. The sample used was a convenience sample of 20 students in my mathematics class. This sample is not indicative of the entire population of third-grade students and cannot be generalized to the entire population.

Dissertation Overview

Chapter one of the Dissertation in Practice includes the identified Problem of Practice, the research question guiding this action research study, and the statement of purpose. Chapter Two reviews the relevant related literature on the effects of number sense on students' mathematics academic progress. The review of related research also includes relevant literature analyzing the ability of the number talks' strategy to improve students' number sense and mathematical proficiency. Chapter Three details the action research methodology used to conduct the present study, a description of the action research design, and the ethical considerations for the current study. Chapter Four reports the results, discoveries, reflections, and analysis of this action research study. Finally, Chapter Five of this Dissertation in Practice focuses on a summary of conclusions obtained from the research study. Chapter Five also includes suggestions for future research.

Conclusion

This action research study's problem of practice is the teacher's third-grade mathematics class' difficulties in effectively and efficiently problem solving when completing multi-step and multi-digit math problems. Research suggests that these students may be exhibiting these difficulties due to a deficit in number sense as demonstrated by their struggle to work with numbers flexibly. Developing number sense is a gradual process (Yang, 2001). However, this can be accomplished through consistent, day by day and frequent focus within each mathematics lesson (Yank, 2001; Thornton & Tucker, 1989). Research shows that successful students have developed number sense and can flexibly think through mathematics problems (Gray and Tall, 1994). Number talks help students to learn to work with numbers flexibly and develop number sense because number talks are designed to influence students to use strategies that focus on number relationships and number theory (Parrish, 2010). Therefore, this study sought to examine the impact that using number talks in the mathematics classroom would have on the development of number sense and mathematical proficiency in students in one third-grade math class.

CHAPTER 2: LITERATURE REVIEW

Introduction

The students in my math class are not unlike many children in the United States today who need to improve in their mathematical performance.

According to the results of the 2015 National Assessment of Educational Progress [NAEP], third-grade students scored lower in mathematics than the previously reported scores in 2013 (National Center for Education Statistics [NCES], 2016). The NAEP measures students' mathematical knowledge and skills, as well as their ability to apply that knowledge to problem-solving. The results of this assessment showed that 60 percent of third-grade students scored below proficiency during the 2015 assessment. This means that the average third grade student in the United States likely lacks the necessary skills to multiply a 2-digit whole number by a 2-digit whole number, divide a 3-digit whole number by a 1-digit whole number, solve multi-step problems involving unit conversions, recognize and explain properties of sums of odd numbers, and extend and describe a numerical pattern in context (NCES, 2016). Research shows that students who struggle with a general understanding of numbers and who also have difficulties using numbers flexibly and applying efficient computation strategies and algorithms, typically lack number sense (Tsao & Lin 2011). Number sense is a student's ability to "construct and discover relationships between quantities and numbers and then examine alternative ways to describe and record these relationships" (Griffin, 2004, p. 39).

There are five components of number sense:

(a) having well-understood number meanings,

(b) developing multiple relationships among numbers,

(c) understanding the relative magnitudes of numbers,

(d) developing intuitions about the relative effect of operating on numbers, and

(e) developing references for measures of common objects (The National Council of Teachers of Mathematics [NCTM], 2000, p. 39).

Students who lack in the area of number sense will also lack in mathematical proficiency because of their deficit in conceptual understanding. According to Kilpatrick, Swafford, and Findell (2001), a person who is proficient in mathematics has conceptual understanding, procedural fluency, strategic competence, adaptive reasoning, and a productive disposition. All these components develop together and help the other components to develop. This study and literature review aim to examine how number talks impact students' number sense development, mathematical proficiency, and dispositions towards mathematics.

Purpose of the Review

Bobis (1996) describes a person that has developed number sense as one that has a conceptual framework of number information, can understand numbers and number relationships and is able to solve mathematical problems using strategies other than traditional algorithms. Tsao and Lin (2012) suggest that, to improve students' number sense, the teacher needs to provide students with opportunities in:

(1) working with concrete materials and familiar ideas, (2) discussing and sharing their discoveries and solutions, (3) composing and recomposing different

arrangements and representations of numbers, (4) investigating the realistic uses of numbers in their everyday world, (5) exploring number patterns and number relationships, (6) creating alternative methods of calculation and estimation, (7) solving realistic problems using a variety of approaches, (8) calculating for a purpose rather than for the sake of calculating, (9) gathering, organizing, displaying and interpreting quantitative information, (10) understanding what characterizes number sense and (preparing) activities that present students with opportunities to explore within that framework, (11) measuring and then making measurement estimates and planning powerful estimation experiences, and (12) exploring very large numbers and representations and providing experience with number lines (Gurganus, 2004; Hope & Small, 1994; Reys, 1994; Sowder, 1992; Tsao & Lin, 2012).

The number talks intervention was chosen to improve students' number sense and mathematical proficiency. Number talks allow teachers to change learners' view of math, teach them number sense, help them develop mental computation skills, and engage them in creative, open mathematics (Stott & Graves, 2015). Researchers have linked the use of number talks to mathematical achievement in areas such as mental calculation, problem-solving, and computational estimation (Hope & Sherrill, 1987; Trafton, 1992; Bobis, 1991; Cobb et al., 1991; Case & Sowder, 1990). At the start of this study, many of my students had negative dispositions towards mathematics due to mathematical challenges they had faced. Because of this research, I also chose to investigate how number talks impacted my students' dispositions towards mathematics. During these number talks, to build a classroom environment in which students persist in their efforts, do the work necessary for mathematical understanding, and share their concepts and problem-solving strategies, no students can be exempt from participation, despite their race, gender, religion, and the stereotypes associated with each (Campbell & Rowan, 1997). No child can limit another student's efforts to participate, and all students are expected to make contributions. The purpose of this literature review was to explore similar studies pertaining to using number talks within the mathematics classroom and the effect this instructional strategy had on students' number sense development and math proficiency. I also explored content on the development of a productive mathematical disposition. Through this literature review, the research on number sense and how it can affect students' mathematics abilities was also explored.

Theoretical Base

Constructivist Theory

The number talks instructional strategy I used in this action research study reflects the ideas of the constructivist theory as it allows students to use their own methods of problem-solving and encourages students to build ideas through interactions with peers.

The constructivist theory states that children construct their mathematical knowledge by reorganizing their mathematical experiences (Cobb, Yackel, & Wood, 1993). Thus, students' personal experiences while interpreting mathematical problems are imperative to developing their mathematical knowledge. With this way of teaching, all methods of problem-solving are valued and encouraged. The role of the constructivist teacher is to guide and support students' ideas and offer appropriate tasks that will bring about the appropriate conceptual reorganization (Cobb, Yackel, & Wood, 1993). With this in mind, I took on the role of the facilitator during number talks to support my students in their conceptual understanding.

Constructivism can be further broken down into cognitive constructivism and social constructivism. The cognitive constructivist belief is based on Piaget's theory that ideas are built personally through experiences (Powell & Kalina, 2009). The cognitive constructivist educator is a guide who leads students into developing their own understanding. In contrast to cognitive constructivism, the social constructivist believes that ideas are built through interactions between others (Powell & Kalina, 2009). Social constructivism was founded on Vygotsky's zone of proximal development theory (Powell & Kalina, 2009). Vygotsky (1978) believed that a task that one could not complete on his or her own, but could successfully complete with the assistance from others, was in their zone of proximal development. This emphasizes Vygotsky's belief that learning is a social activity and reiterates the idea of using number talks and classroom discourse to develop students' mathematical number sense and skill. Mathematics should not merely be the application of rules and finding of answers. It should involve the construction and discovery of relationships between quantities and numbers, and it should examine alternative ways to describe and record those relationships (Griffin, 2004).

The constructivist approach to learning mathematics has been that mathematics is "a matter of reorganizing activity, where activity is interpreted broadly to include conceptual activity or thought" (Cobb et al., 1991, p. 5). Learning mathematics involves reconstructing existing ideas using new information, ways of thinking, and understanding. Mathematics is not solely regurgitation of facts. While learning mathematics, "students clarify their ideas and forge links between new knowledge and their previous understandings" (Watson & Young, 1989, p. 126). One of the major goals of mathematics instruction under the constructivist theory is that students should be developing more complex and abstract mathematical structures so that they are increasingly able to solve a variety of problems (Clements & Battista, 1990). Secondly, students should not see mathematics as just receiving knowledge from their teacher, but as making sense of and communicating about mathematics. There are four basic tenets of constructivism as outlined by Clements and Battista (1990):

a) Knowledge is actively created or invented by the child;
b) Children create new mathematical knowledge by integrating it into their existing structures of knowledge;
c) Mathematics learning should be thought of as a process of adapting to and organizing one's quantitative world, and;
d) Learning is a process. In a constructivist classroom, students participate in social discourse involving explanation, negotiation, sharing, and evaluation (p. 34-35).

When teachers demand that students use set mathematical methods, students' beliefs about the nature of mathematics change from viewing mathematics as sense-making to viewing it as learning set procedures that makes little sense.

This action research study reflects the constructivist theory in that students are encouraged to construct new mathematical computation strategies using the information they have learned. This practice assists students in developing number sense and mathematical proficiency. When students begin to create new mathematical knowledge and adapt their mathematical thinking, they begin to develop more positive feelings about math and their mathematical abilities. During number talks, students were asked to develop strategies based on their understanding, explain and justify their strategies and answers, and discuss these strategies with their peers and teacher. This practice reflects the ideas of Vygotsky and social constructivism because students' conceptual understanding and development and use of problem-solving strategies are enhanced by the sharing and discussions coming from peers. Finally, like the cognitive constructivist educator, I acted as a guide during number talks and led students in developing their own understanding of mathematics and efficient computational strategies by prompting students to further explain steps within the strategies they used, asking students to justify their use of specific strategies, and prompting students to develop additional strategies.

Mathematics Proficiency

When students understand numbers, they will invent algorithms for carrying out computations; therefore, it is vital for educators to provide students with the opportunities to develop strategies and to make connections between concepts, procedures, and numbers (National Research Council, 2001). This is the purpose of applying number talks intervention to mathematics instruction. This invention of algorithms or procedures by individual students for multi-digit addition and subtraction along with simple multiplication and division was used to enhance my students' number sense and accuracy in mathematical computations by helping them to better understand numbers and operations (Carroll & Porter, 1997).

The National Research Council (2001) refers to mathematical proficiency as a combination of conceptual understanding, procedural fluency, strategic competence, adaptive reasoning, and productive disposition. Students who have the ability to use knowledge of mathematics in appropriate circumstances, are flexible and resourceful in problem-solving and have a mathematical disposition which includes a willingness to persevere are proficient in mathematics (Schoenfeld, 2007). These qualities are interdependent of each other in students who are successful in mathematics and help each other to develop. The knowledge of these strands has implications for how students acquire proficiency, how teachers develop proficiency in students, and how teachers are taught to achieve proficiency in their students (National Research Council, 2001). Research shows evidence that understanding is the basis for developing procedural fluency (Siegler, 2003; National Research Council, 2001). Instructional programs that emphasize the understanding of algorithms before students are able to use algorithms has been shown to increase both conceptual knowledge and procedural knowledge in students (Fuson et al., 1997; National Research Council, 2001). Comprehension of mathematical concepts, operations, and relations on conceptual understanding, "is important for the development of procedural fluency, while fluent procedural knowledge supports the development of further understanding and learning" (National Research Council, 2001, p. 196). Typically, students develop systematic patterns of errors when they fail to grasp or connect concepts to the procedures. The development of understanding and fluency happens when students' use of computational procedures reflect their understanding of numbers. Students who have an understanding of mathematical concepts will invent multiple procedures for solving mathematical problems which will eventually allow them to make sense of the standard algorithms. By including the number talks strategy into my mathematics instruction, my students were given a safe environment to invent mathematical procedures that made sense to them and share with and learn from their peers. By posing mathematical problems during number talks and giving students time to use past experiences to develop computational strategies that they invent and understand my goal was to increase my students' conceptual and procedural knowledge which I hypothesized would lead to a more productive disposition towards mathematics. "Students gain confidence in their ability to do mathematics when they use strategies that they understand. Students understand the strategies they have invented to solve problems in their prior experience" (Chambers, 1996, p. 94).

Learning to use algorithms is an essential step in developing mathematical proficiency. Students use algorithms to solve problems in different situations and with different numbers while using the same procedures. Students who struggle in mathematics may have difficulty developing efficient algorithms and may need additional assistance in understanding mathematical concepts. "For these students, the process of learning algorithms involves listening to someone else explain an algorithm and trying it out, all the while trying to make sense of it" (National Research Council, 2001, p. 197). Research shows that, for this to be beneficial to students, the procedure must be explained to the student, and they must have concrete material that supports their understanding. Data show that some commonalities of effective instructional approaches to helping students develop a mathematical understanding include: (a) procedures that are easily understood, (b) encouragement to use methods that they understand, and (c) instructional supports (Carpenter et al., 1998; National Research Council, 2001). This is why, during number talks, I recorded the problem on the board along with the strategies students used to solve the problem.

This research on mathematical proficiency informed my decision to incorporate number talks within my mathematics instruction for my third-grade class. Number talks not only gave my students the opportunity to develop mathematical algorithms and learn to apply them efficiently and flexibly, but they also gave my students the opportunity to explain how they used their algorithms and to learn new algorithms from their peers.

Mathematical Classroom Discourse

The National Council of Teachers of Mathematics' (2000) process standard for communication includes enabling students to organize and consolidate their mathematical thinking through communication; communicate their mathematical thinking coherently and clearly to peers, teachers, and others; analyze and evaluate the mathematical thinking and strategies of others; and use the language of mathematics to express mathematical ideas precisely (National Council of Teachers of Mathematics, 2000). Research findings promote using classroom discourse between teacher and students and among students to further the learning of mathematics concepts as a social endeavor (Ball, 1993; White, 2003). Productive classroom communication includes students voicing their reasoning about mathematical concepts and engaging in the ideas of others' (Webb, Franke, Ing, Wong, Shin, & Turrou, 2014). Discourse in the mathematics classroom can be organized into four key themes:

(1) clarifying how students and teachers communicate in the classroom,

(2) scaffolding students' ideas to move thinking forward,

(3) fine-tuning mathematical thinking through language, and

(4) shaping mathematical argumentation (Walshaw & Anthony, 2008; Griffin, League, Griffin, & Bae, 2013, p. 11).

To enhance my students' conceptual understanding was the purpose of using number talks in my classroom.

Students who spent more time solving a smaller number of problems, but were asked to explain their strategies for solving the problems, showed higher levels of performance as compared to their more traditionally-taught peers (Hiebert & Wearne, 1993). Students who grow accustomed to using language in the mathematics class seem to enjoy it and realize they gain from it (Campbell & Rowan, 1997). This also includes students with limited English proficiency who are typically allowed to remove language and context. Students who are English language learners should not be forced to allow their mathematical concept development to suffer while they learn English (Flores, 1997). These students should be given multiple avenues to gain and practice higher-order thinking such as using a calculator because they lack basic math skills or being able to reason and explain in their Native language because they lack basic skills in English. Students learn through working with concrete manipulatives, but the central learning comes from reflecting on their experiences with the manipulatives (Flores, 1997; Pirie, 1988). Students need the opportunity to reflect and discuss using developmentally appropriate vocabulary (Flores, 1997).

Research findings show that there are multiple ways in which students who participate in mathematical discourse can benefit. The first way is by explaining ideas to others. When teaching, students are encouraged to monitor their thinking and are offered the chance to catch their own mistakes (Webb, Franke, Ing, Wong, Shin, & Turrou, 2014). Second, listening to other students' ideas also encourages students to monitor their thinking. Students will be able to identify gaps in knowledge and misconceptions. Third, having to justify their ideas allows students to participate in a variety of learning processes. These processes include re-examining and questioning one's own ideas and beliefs; seeking new information to correct misconceptions, filling in gaps in understanding, developing new ideas, or reconciling conflicting viewpoints; building new connections between pieces of information or concepts; and linking new information to information previously learned (Bargh and Schul, 1980, Chi, 2000; Wittrock, 1990). Research has found that discussing and comparing different algorithms and problem-solving methods can provide students with opportunities to extend their understanding of mathematical concepts (National Research Council, 2001). Therefore, the focus on mathematics instruction should be on understanding and explaining, not simply the use of arithmetic algorithms. Easley, Taylor, and Taylor (1990) found that encouraging dialogue and the diversity of ideas can lead to a more solid mathematical foundation for students. Campbell and Rowan (1997) with Project IMPACT suggests incorporating into the mathematics classroom meaningful real-life problems targeted at a higher instructional level. Students should be given time to brainstorm strategies to solve the real-life problem before solving the problem.

There are many misconceptions in reference to classroom discourse. One of those misconceptions is that many teachers believe that they must refrain from providing any guidance to students during their class' mathematical discourse. Some teachers believe this will take away from students being able to think freely (Stein, Engle, Smith, & Hughes (2008). Stein et al. (2008) uses the term "show and tells" to describe the classroom discourse environment in which students are given a task to solve in a group, then asked to explain their solution to the class. These discussions would involve limited to no commentary from the teacher to connect students' methods of problem-solving or intertwining mathematical concepts. This type of "show and tell" discourse does not assist students in developing their mathematical thinking (Stein et al., 2008). Discourse in the mathematics classroom should focus on crucial mathematical ideas and provide appropriate tasks for students (Franke, Kazemi, & Battey, 2007). It is critical for the teacher to begin with a task that will give students the opportunity to share their thinking and compare different approaches. These tasks should connect to core mathematical ideas, have multiple strategies to solve the task, involve multiple representations, and require students to explain and justify their solution in oral and/or written form (Silver & Stein, 1996). Stein et al. (2008) identified five practices for facilitating discourse in the mathematics classroom around cognitively demanding tasks. These five practices are:

> (1) anticipating likely student responses to cognitively demanding mathematical tasks,
>
> (2) monitoring students' responses to the tasks during the explore phase,
>
> (3) selecting certain students to present their mathematical responses during the discuss-and-summarize phase,
>
> (4) purposefully sequencing the student responses that will be displayed, and
>
> (5) helping the class make mathematical connections between different students' responses and between students' responses and the key ideas (Stein et al., 2008, p. 321).

In this study, I used number talks to give students the opportunity to explain their thinking and discuss the strategies. This discourse helped students to develop an understanding of number relationships and computational strategies.

Productive Mathematical Dispositions

Students' mathematical disposition is their attitudes, beliefs, and views about mathematics (Gainsburg, 2007). Mathematical dispositions can be just as influential on students' mathematical behavior and learning as the mastery of content (Boaler, 2007; Burton, 2004). One's mathematical disposition informs their point of view on "what mathematics is about; what it can and should be used for; who does it; and the role it plays, or should play, in one's activities and subcultures" (Gainsburg, 2007, p. 478). Instructional practices can foster counter-productive dispositions when students are always expected to use traditional algorithms when solving problems. Students begin to believe that mathematical ability requires unique talents and mathematics is a rule-driven, school-only activity in which problems have only one correct solution (Lampert, 1990; Schoenfeld, 1992). This view can cause students to try to escape mathematics and mathematical challenges. Because of the adverse effects of a counter-productive mathematical disposition, teachers are encouraged to establish classroom practices that bring authenticity to the mathematics classroom (NCTM, 1991; National Research Council, 2001). Classroom practices that foster productive dispositions toward mathematics include instilling a view that mathematics is about understanding, sense-making, communicating, discovering patterns, collaboration, and all people can do it (Gainsburg, 2007; Ball 1993; Boaler, 1997; McClain & Cobb, 2001).

For this action research study, I set out to develop a classroom environment that would foster productive mathematical dispositions within my students. I used number talks as an instructional strategy because research showed, when implemented correctly, they would help foster an understanding of mathematics for my students through discovery, communication, and collaboration. Number talks offered my students a safe space for them to invent computation strategies that made sense to them and a space to share and learn freely from their peers. By incorporating number talks into my mathematics instructional strategies, it helped students see that mathematics is not a fixed ability and they can expand their ability. This insight helps students to be more motivated in mathematics and develop a more productive disposition towards mathematics.

Number Sense

In mathematics, becoming a good problem-solver "may be as much a matter of acquiring the habits and dispositions of interpretation and sense-making as of acquiring any particular set of skills, strategies, or knowledge" (Campbell & Rowan, 1997, p. 61; Resnick, 1988). Number sense has been identified by the National Council of Teachers of Mathematics as one of the fundamental ideas of mathematics for students. Number sense is key to solving basic mathematical computations (NCTM, 2000). Number sense is a student's "fluidity and flexibility with numbers, the sense of what numbers mean, and an ability to perform mental mathematics and to look at the world and make comparisons" (Gersten & Chard, 1999, p. 19). Number sense can lead to the ability to automatically use mathematical information (Gersten & Chard, 1999). Research has linked the lack of number sense to learning disabilities but has linked number sense instruction to significant reductions in mathematics failure in the early grades (Gersten & Chard, 1999; Griffin, Case, & Siegler, 1994; Geary, 1993; McCloskey & Macaruso, 1995; Jordan, Glutting, & Ramineni, 2010).

In a study conducted by Gray and Tall (1994), researchers examined how low-achieving and high-achieving students solve number problems. The researchers hypothesized that the higher-achieving students would use more mental math strategies when solving mathematical problems as compared to low-achieving students. Results showed that more successful students were able to flexibly think through the mathematical problems, while the low-achieving students used more complicated strategies to solve problems (Gray and Tall, 1994). Researchers concluded that low-achieving students were not low-achieving solely because they knew less, but were low-achieving because they did not use numbers flexibly (Gray and Tall, 1994).

When teachers use strategies to help students develop number sense, research shows that this knowledge can have a lasting effect on students. Number sense is a powerful predictor of later math outcomes (Jordan, Glutting, & Ramineni, 2010; Andrews & Sayers. 2015; Boaler, 2015, p. 2). In a study conducted on children who were assessed at the end of first grade and at the end of 3rd grade, researchers found that students' overall performance on the number sense measure and their growth rate between kindergarten and first grade predicted their overall performance and growth rate in general mathematics achievement between first and third grades (Jordan, Glutting, & Ramineni, 2010). Similarly, in a study where number sense activities were conducted as supplementary teaching materials in a fifth-grade intervention group, researchers found that the group's testing average increased by forty-four percent between the pretest and after the intervention (Yang, 2003). The results of data collected on knowledge retention of number sense revealed that student learning was meaningful and significant.

Number sense is attained when students are given opportunities to discover and construct relationships among quantities, counting numbers, and numerical symbols (Griffin, 2004). Number sense develops over time through exploration of numbers and visualization of numbers in a variety of contexts. The key to helping students develop number sense is providing students with activities for making connections, exploring and discussing concepts, and following an appropriate sequence of concepts (Griffin, 2004).

Number talks incorporated into the mathematics instructional routine during this eight-week action research study was used to help students develop number sense and increase more positive mathematics outcomes.

Number talks

To develop students' understanding of mathematics, instructional strategies are required in which students "investigate the meaning of facts through hands-on activities and thoughtful discussions, explore strategies to support their understanding of numbers, and engage in the strategic practice to memorize the facts" (O'Connell & SanGiovanni, 2011, p. 5). One pedagogical approach used to increase students' mathematical understanding is number talks. Number talks are classroom discussions that cover strategies students have developed and/or used to solve computational problems (Parrish, 2010). Number talks allow students to add, subtract, multiply, and divide numbers using flexible problem-solving strategies and algorithms of their choice rather than mandated procedures. Number talks are short sessions, in addition to the regular mathematics lesson. During number talks, the teacher will write a problem on the board. Students will then spend time mentally solving the problem in as many ways as they can think of. Mental computation is used during number talks to encourage students to find numerical relationships to help them solve the problem. After the allotted thinking time, the teacher records all solutions and strategies shared by students. Students then explain and justify their strategies while the teacher acts as a facilitator prompting students and asking questions to promote productive discussions and learning. Number talks include:

(a) a variety of problems at various levels of difficulty,

(b) a safe environment for students to work, think, and share,

(c) concrete models,

(d) opportunities to think about their strategies,

(e) interaction with the teacher and peers, and

(f) opportunities for self-correction.

Discourse during number talks is key to successful classroom number talks. A discourse that includes reflection and sharing of strategies allows students to develop more accuracy to produce solutions to problems, efficiency in choosing an appropriate strategy, and flexibility in using number relationships (Parrish, 2010; Russell, 2000). Number talks' discourse also allows students to learn about their thinking, gives students the opportunity to learn new strategies, and allows the teacher to assess students' understanding (Presmeg, 1986; Mason, 1992). O'Nan (2000) used number talks to increase the number of methods third-grade students used to solve mental math problems and increase the number of two-digit addition problems students could complete correctly in two minutes. The results of O'Nan's (2002) six-week study showed that statistically significant gains were found in the number of strategies students could produce and the number of two-digit addition problems they could solve within two minutes.

Cultural Diversity

Mathematics is typically thought to be a subject that is not affected by culture, so being aware of how culture affects learning is particularly important (Nasir, Hand, &

Taylor, 2008; White et al., 2016). Student achievement in mathematics correlates with high expectations for educational attainment (Croom, 1997). Therefore, it is imperative for the teacher not to assume students' low mathematics achievement is due to stereotypical assessments of underrepresented groups. For example, research has shown that mathematics expectations for traditionally marginalized students are generally low (Campbell & Rowan, 1997). Many girls and minorities are underserved, receive less encouragement, and have fewer opportunities to learn mathematics (American Association of University Women, 1992; Oakes, 1990; Croom, 1997). Lucille Croom (1997) suggests three ways to increase female and minority students' interest in mathematics: (1) modifying deep-rooted beliefs about who can learn mathematics, (2) making mathematics and science instruction more attractive, and (3) developing effective strategies to stimulate students' interest in these areas as college majors or as career choices (p. 3). Studies have shown that mathematical achievement between African American and Hispanic students and white students are disproportionate (Walker & McCoy, 1997; Secada, 1992; Stiff & Harvey, 1988; Oakes, 1988). Walker and McCoy (1997) suggest that these findings show that something is happening in America's schools that are creating obstacles and resulting in detrimental effects to the mathematical achievement of minority students. Studies suggest that African American students tend to be more flexible and open-minded in their mathematics learning (Shade, 1992; Malloy, 1997). Generally, African American students learn mathematics in ways characterized by social and affective emphases (Malloy, 1997). "Social learning is an integral part of the school experience for many African American students" and influences how they learn mathematics (Malloy, 1997, p. 24; Slavin, 1991). Therefore, the teacher believes number talks will be an effective strategy for the students in her mathematics class. Teachers' expectations of their students generally change as they reflect on the ideas offered by their students and their strengths (Campbell & Rowan, 1997).

As someone who works with a diverse group of students, the number talks learning strategy will give students the opportunity to share their unique views and perspectives on mathematics. "If group activities are specifically designed to take advantage of student diversity, then learning will be deep and powerful" (Moyer, Cai, & Grampp, 1997, p. 152). Mathematics learning is an individual process in which each individual constructs their own knowledge and responds to learning in a unique way (Cobb, 1994; Moyer, Cai, & Grampp, 1997). It is the teacher's duty to give students the opportunity to construct their meaning.

Historical Context

Thorndike's Stimulus-Response Bond Theory of Learning

At the beginning of the twentieth century, Edward L. Thorndike, president of the American Psychological Association, led a mission to make schools more efficient and effective at educating (Ellis & Berry, 2005). Thorndike believed that mathematics was best learned with the more traditional method of skill and drill. For learning to occur, Thorndike believed that the teaching of mathematics should be "carefully sequenced, explicitly taught, and then practiced with much repetition" (Ellis & Berry, 2005, p. 8). The educational community widely embraced Thorndike's Stimulus-Response Bond Theory of Learning for much of the twentieth century. His theory, though largely accepted, denied students' abilities to reason about mathematical concepts and did not address the mathematical thinking students needed to problem solve. Thorndike's

Stimulus-Response Bond theory did not acknowledge “the experiences the students bring to mathematics or the meaning they make of what is learned” (Ellis & Berry, 2005, p. 8).

John Dewey and Progressivism

At the turn of the twentieth century, John Dewey opposed the traditional school system practices for many reasons. Among those were forced rote memorization and children continually working individually (Dewey, 1938). Dewey (1938) believed that genuine education comes from experiences that arouse curiosity, strengthens initiative, and “sets up desires and purposes that are sufficiently intense” (p. 38). Similar to the aim of number talks, Dewey believed in the importance of connecting experiences of the past to new situations in the present. During number talks, students use what they know about numbers to apply this information to help them develop computational strategies that will assist them in solving new mathematical problems. In *John Dewey Experience & Education,* Dewey (1938) discusses the importance of experiences. In unfamiliar situations in which the outcome is unknown, one reviews his or her past experiences. One must relate the similarities between the new situation and prior experiences. Once similarities are found between the past and the present, one can then apply that information to make informed judgments. This process involves complex, intellectual, operational steps according to Dewey (1938).

These steps include:

> (a) observation of surrounding conditions; (b) knowledge of what has happened in similar situations in the past, as knowledge obtained partly by recollection and partly from the information, advice, and warning of those who have had a wider

experience; and (c) judgment which puts together what is observed and what is recalled to see what they signify (Dewey, 1938, p. 69).

This action research study incorporates Dewey's (1938) beliefs on experience and education. The number talks intervention, which is used to develop number sense in this class, required students to use their prior experiences with similar types of mathematical problems and numbers to solve new problems. Students had to decide on appropriate computational strategies based on their prior experiences.

Mental Computation Versus Paper-and-Pencil

The pendulum has swung back and forth throughout American history between mathematics instruction emphasizing mental computation and mathematics instruction emphasizing paper-and-pencil computation. Smith (1913) states that during the nineteenth century, concern was made toward how slow students were completing written arithmetic (cited in Thompson, 1991). This concern resulted in changes to the school curriculum, which included adding oral arithmetic to the mathematics curriculum. Oral arithmetic is mathematics problems given to students orally for them to compute mentally. During this time, mental math became an integral part of instruction. Mental computation instruction involved oral drills of multi-step problems and was used to improve mental discipline (Thompson, 1991; Buchanan, 1978; Reyes, 1985).

By the twentieth century, the curriculum in American schools had returned to emphasizing paper-and-pencil computation and de-emphasizing mental computations. Some mathematics scholars did, however, advocate for a more balanced approach to mathematics instruction in American schools (Suzzallo, 1912). These scholars understood that some calculations could be done mentally, but others required more instructional time, demonstration, and paper-and-pencil algorithms to master.

Again, the pendulum had swung and between the 1930's and 1960's Americans believed more emphasis should be on mental computations because students were becoming too reliant on paper-and-pencil calculations. Reys and Reys (1986) contend that this issue arises because mental math is more useful outside of the classroom. Therefore, mathematics in the classroom should relate to more real-life situations and mental computations should emphasize mathematical reasoning and understanding. Some educators believe that the development of number sense can be hindered by the traditional teaching of paper-and-pencil algorithms (Burns, 1994).

In the late twentieth century, the National Council of Teachers of Mathematics (NCTM, 1989) stated that mathematics instruction should focus on applying computational strategies. Specifically, the new set of standards stated that children should be able to choose and apply an appropriate computation strategy based on the mathematical problem they are given. By helping students to apply their knowledge of number sense through mental math strategies and flexibility, teachers are helping students to not rely on paper-and-pencil algorithms (Calvert, 1999; NCTM, 1995; Tsao, 2004).

This research on mental computation versus paper-and-pencil methods has implications for this action research study and the best strategies used to help students to develop number sense and gain mathematical proficiency. The number talks strategy incorporates both of these methods as students learn to use multiple computation strategies based on which is most appropriate and efficient.

Rote Memorization

Early American schools began as a way to maintain the authority of the government and religion (Spring, 2014). Therefore, the primary focus of education was to teach citizens how to read and write so that they could obey the laws of the government, obey religious laws, and read religious texts. Eventually, arithmetic was taught in schools, but mainly drilling. In the 1980's much research was conducted to demonstrate the effectiveness of drill-and-practice to teach mathematics (Gagne, 1983; Garnett & Fleischner, 1983; Tournaki, 2003). However, when the drill-and-practice method was used, certain subgroups of students - particularly those with learning disabilities and attention-deficit disorder - did not achieve mathematical success. When using the drill-and-practice method, some students were not able to automatize basic math facts. Siegler (1988) suggests that these students were unsuccessful at automaticity because using drill-and-practice methods does not consider mathematical facts as mathematical problems to solve when they are first introduced.

For many years and still today, drill-and-practice is the strategy teachers use to teach basic math facts and the strategy used to develop automaticity and fluency in the mathematics class. Although many still use this strategy, research shows that the memorization of facts through drill-and-practice methods such as times table repetition, practice, and timed testing is unnecessary damaging classroom practice (Boaler, 2015). To enhance learning and automaticity in the mathematics class, students need to understand mathematics skills, be taught how to use effective problem-solving strategies and to use numbers in different ways and situations (Tournaki, 2003; Boaler, 2015).

As many classroom teachers in the elementary classrooms believe that rote memorization is an effective way for students to master basic math facts, number talks help students to not only learn these facts but also understand their knowledge and develop computational strategies without the anxiety that drill-and-practice may cause.

The National Defense Education Act

Since the 1950's Americans have been concerned with how the United States compared to other countries regarding global military and economics (Spring, 2014). American schools have been blamed for this lag and complaints were made about their poor quality. One of the leaders of this movement was Arthur Bestor who voiced his opinion that Americans' intellectual life was in danger due to anti-intellectual tendencies (Spring, 2014). Bestor blamed these "anti-intellectual tendencies" on American educators and proposed a change (Spring, 2014, p. 366). Bestor believed that the American school curriculum included too many trivial skills and should focus on more traditional disciplines such as mathematics, science, history, and foreign language. Bestor believed this change in the American school curriculum would create "a new respect in the student and in the home for knowledge and cultural achievement" (Spring, 2014, p. 367). Although the American schools did not adopt this proposal, Bestor's ideas did gain much support from people believing in the idea of the anti-intellectual quality of schools.

One of the most voiced critics of the quality of the American schools was Vice Admiral Hyman G. Rickover who believed that the United States was unable to compete with the Soviet Union in technology and military because American schools were not properly educating its youth as scientists and engineers (Spring, 2014). These attacks on the American schools led to the National Defense Education Act (Spring, 2014). In 1957 the Soviet Union launched *Sputnik I,* which further confirmed to Americans that they were losing the technological and military race. American schools were blamed for this deficit, and a greater push was made to focus on mathematics and science in the school curriculum (Spring, 2014). President Dwight D. Eisenhower proposed nationwide testing of high school students, incentives for students who pursue scientific and professional studies, and quality teaching in mathematics and science in order for the United States to compete with the Soviet Union in military power, technological advancement, and specialized research and education (Spring, 2014). Congress' response was the National Defense Education Act. The National Defense Education Act included:

a) Increasing appropriations for educational activities,
b) providing funds for testing programs and guidance and counseling services,
c) hiring science teachers and purchasing equipment and materials to improve science and mathematics teaching,
d) creating a fellowship program to prepare students for a career in college teaching, and
e) adding emphasis on foreign languages to compete with the Soviet Union for control for influence over other nations (Spring, 2014, p. 369-370).

The passing of the National Defense Education Act is significant to the current research study as it is the result of America's major emphasis on mathematics curriculum. The passing of the National Defense Education Act and the dissatisfaction of the American people towards American schools and educators show the progression of mathematics curriculum from not being valued at all to having significant implications for America's place among other countries.

Glossary of Key Concepts

***Action Research:* "**Systematic inquiry conducted by teachers, administrators, counselors, or others with a vested interest in the teaching and learning process or environment for the purpose of gathering information about how their particular schools operate, how they teach, and how their students learn" (Mills, 2011; Mertler, 2014, p. 4).

Adaptive Reasoning: "capacity for logical thought, reflection, explanation, and justification" (National Research Council, 2001, p. 5)

Algorithm: "procedures that can be executed in the same way to solve a variety of problems arising from different situations and involving different numbers" (National Research Council, 2001, p. 7)

Automaticity: "students' ability to effortlessly recall a fact" (O'Connell & SanGiovanni, 2011, p. 2)

Basic Math Facts: A relatively small set of addition, subtraction, multiplication, and division questions (Boychuk & Cui, 2014).

Conceptual Understanding: "Comprehension of mathematical concepts, operations, and relations" (National Research Council, 2001, p. 5)

Mathematical Proficiency: A combination of conceptual understanding, procedural fluency, strategic competence, adaptive reasoning, and productive disposition (The National Research Council, 2001).

Number Sense: "A person's general understanding of numbers and operations along with the ability and inclination to use this understanding in flexible ways to make mathematical judgments and to develop useful strategies for handling numbers and operations" (McIntosh, Reys, & Reys, 1992, p. 3).

Number talks: A ten to fifteen-minute teaching strategy that involves posing an abstract math problem and asking students to solve the problem mentally. The different methods for solving the problem can then be collected by the teacher and discussed with the class or small group on why they worked (Boaler, 2015).

Procedural Fluency: "Skill in carrying out procedures flexibly, accurately, efficiently, and appropriately" (National Research Council, 2001, p. 5)

Productive Disposition: "habitual inclination to see mathematics as sensible, useful, and worthwhile, coupled with a belief in diligence and one's own efficacy" (National Research Council, 2001, p. 5)

Strategic Competence: "ability to formulate, represent, and solve mathematical problems" (National Research Council, 2001, p. 5)

Summary and Conclusion

This action research study's problem of practice centers on the students of one third-grade mathematics class. These students have difficulties in problem-solving, computing multi-digit multiplication problems, and solving multi-step equations using the four operations of addition, subtraction, multiplication, and division. These students also struggle to develop and implement effective and efficient computation strategies when faced with mathematical problems. Action research was used for this study to examine the impact of number talks on students' number sense development and developments in their mathematical proficiency.

Historically, in the United States, mathematics instruction has emphasized drill-and-practice instead of conceptual knowledge and understanding of mathematical skills and strategies. However, studies show that students who have number sense tend to be more successful in mathematics and are able to transfer their knowledge to new situations (Gray & Tall, 1994). Number talks were used in this study to help students develop number sense as it has been shown to enrich students mathematical understanding and help them develop flexibility and fluency with numbers (Parrish, 2010).

CHAPTER 3: METHODOLOGY

Introduction

Action research allows one to study a real school in order to improve the actions and results within that school (Schmuck, 1997). McMillan (2004) states that with action research, one wants to solve a problem immediately, improve practice, or help make a decision in one or a few classrooms or schools (as cited in Mertler, 2014, p.13). In action research, teachers study their own classroom (Mertler, 2014). The present action research study followed Mertler's (2014) recommended action research methodological cycle to investigate the impact of incorporating number talks into the mathematics instruction of one third-grade class. The current study explored the following research questions:

1. *What is the impact of the number talks intervention on third-grade students' number sense development and mathematical proficiency?*
2. *What is the impact of the number talks intervention on third-grade students' dispositions towards mathematics?*

As a teacher, one must be willing to examine their practice and how students learn (Mertler, 2014). An action research methodology was used to understand the problem of practice and improve the quality and effectiveness of teaching practices in my classroom. The planning phase of this study involved identifying the problem of practice, reviewing related literature, and developing a research plan. The acting phase included the collection and analysis of quantitative data which included a teacher-created number sense assessment and the Measures of Academic Progress [MAP] assessment created by the Northwest Evaluation Association [NWEA]. This Numbers Sense and Operations instructional area of the MAP assessment was used to identify students' current levels of number sense development and their ability to use their number sense to solve various problems. Qualitative data was also collected through semi-structured group interviews to understand students' current feelings about mathematics and how they perceived themselves as math students. These feelings refer to students' mathematical dispositions. Following the completion of pretests, number talks were conducted during the mathematics class with a goal of helping students to develop number sense and mathematical proficiency. Number talks were also used to encourage a more productive disposition within students as they gained confidence in their mathematical abilities. For this study, number talks were incorporated into the mathematics instruction three days per week for eight weeks.

At the end of the eight-weeks, students were given a number sense classroom assessment to assess their present ability to use their number sense to correctly answer a set of mathematics problems accurately, efficiently, and flexibly. Students were also given the Number Sense and Operations instructional area of the mathematics MAP assessment to determine their current level of number sense development. Again, a semi-structured group interview was held to determine students' current mathematical dispositions and their feelings about the number talks intervention. The results of the assessments and interview were then analyzed to determine if the number talks intervention had an impact on students' number sense development, mathematical proficiency, and dispositions towards mathematics.

After the acting phase, the next cycle of this action research study was planned to train the remaining third-grade teachers at Junior Elementary School to implement number talks in each third-grade mathematics class with all students during the upcoming school year. Finally, the reflecting phase was completed as I reflected on my study and the results of this study were shared with my third-grade colleagues. The process of this study was also reflected upon, and changes that needed to be made for future action research studies were discussed.

Purpose of the Study

The purpose of this action research study was to examine the impact number talks had on third-grade students' mathematical achievement in the area of number sense. I also looked at how the incorporation of number talks would affect the mathematical dispositions of my third-grade students. The National Council of Teachers of Mathematics (2000) note that students who have developed number sense "(1) Understand numbers, ways of representing numbers, relationships among numbers, and number systems; (2) Understand meanings of operations and how they related to one another; and (3) Compute fluently and make reasonable estimates" (National Council of Teachers of Mathematics, 2000, p. 32). One of the key components of number sense and mathematical proficiency is the ability to think about number relationships (Jordan & Dyson, 2014; Griffin, 2004). Deficits in the capacity to think about number relationships are also associated with learning disabilities (Jordan & Dyson, 2014). Research shows that students who exhibit difficulties in mathematics tend to use complicated strategies to solve complex math problems instead of using numbers flexibly and finding relationships between numbers (Gray & Tall, 1994). However, researchers believe that all students can be successful in mathematics when difficulties are caught early and research-based interventions are provided (Geary, Hoard, Burd-Craven, Nugent & Numtee, 2005; Jordan & Dyson, 2014). I chose to incorporate the use of number talks into my mathematics instruction to help my students understand numbers. I hypothesized that this new strategy would help my students to think more about number relationships and use that knowledge to find more success in mathematics. As the teacher, I hoped the number talks would give me a better opportunity to catch and address students' misconceptions so that they could find more success in mathematics and have a more productive disposition toward the subject.

For students who have a weak number sense, number sense can be developed through process-oriented activities, effective teaching, and a good learning environment (Yang, 2002). Researchers in Taiwan used process-oriented activities to develop fractional number sense in sixth-grade students. These activities were conducted in a classroom of twenty-nine students who were placed into small groups and given the opportunity to discuss their thinking in solving a "challenge question" provided by the teacher (Yang, 2002). Results showed that not only was the teacher able to develop fractional number sense in students, process-oriented activities were able also to help students to develop their understanding of number sense from a pictorial representation to a symbolic representation.

Research shows that students and teachers prefer classrooms in which students learn number sense through engaging activities that focus on mathematical understanding (Boaler, Williams, & Confer, 2014 as cited in Stott & Graves, 2015 p. 313). Scott and Graves (2015) explain that through number talks, teachers can "change learners' views of mathematics, teach them number sense, help them develop mental math skills and engage them in creative, open mathematics" (Stott & Graves, 2015, p. 314).

In this study, I aimed to reach these goals throughout this action research study's eight-week intervention period to increase students' achievement in mathematics. Ruter (2015) states that number talks were developed after the observation of many students and adults treating math as rules and procedures to be memorized without any real understanding of the rules or procedures. According to Parker (1993), number talks are the gateway to creating mathematically confident students who are engaged in number discussions (as cited in Celski, 2009, p. 7). My aim was to increase students' number sense development by increasing their understanding of numbers and number relationships. I predicted that the increase in number sense development would also lead to an increase in mathematical proficiency and a more productive disposition towards mathematics for my third-grade students

Statement of the Problem of Practice

When I began teaching, I noticed that many of my students could not recall basic math facts now apply the facts they did know to solve higher level mathematical problems such as problems involving numbers with multiple digits and multi-step problems. Like many teachers, I employed the practice of emphasizing memorization of math facts through practice with flashcards and multiplication timed testing but had no success. According to research, when students do not understand the process used to work with numbers or do not know to use a variety of strategies to solve problems, they exhibit many of the same problems my students were having in mathematics (Boaler, 2015). Many of my students were continually using the same strategies they had previously memorized from previously taught instruction on basic facts to solve the more complex math problems they now were responsible for completing. My students did not see success with this strategy as they applied it to more complex concepts. However, my students did not have the number sense and understanding to use numerical relationships to solve these problems more appropriately. Memorization is very ineffective when solving complex mathematical problems (Gray & Tall, 1994). The use of number sense to understand patterns within numbers instead of memorizing algorithms, I hypothesized, would help my students be more successful in this third-grade math class and into adulthood.

Research Design

An action research design was used to examine the research question of the study. The purpose of the action research methodology is to be more efficient at achieving desirable educational outcomes (Mertler, 2014). Mills (2011) states that action research is conducted by those who have a personal interest in the teaching and learning process or the educational environment to gather information on their school's operation, teaching, and learning (as cited in Mertler, 2014). The process of action research allows teachers to study their classrooms to understand them better and improve their quality and effectiveness by focusing on the unique characteristics of the population being studied (Mertler, 2014). An important aspect of action research is being reflective. To be a reflective teacher, according to Parsons and Brown (2002), one must critically explore what they have done, how they did it, and its effects (as cited in Mertler, 2014) This action research study was used to examine the effectiveness of my teaching practices in my third-grade mathematics class. I identified the number talks instructional strategy that, according to research, would help me to better meet the mathematical needs of my students compared to my current instructional practices. Action research allowed me to continue in my role as teacher, but also take on the role as researcher and examine how this number talks intervention impacted my students.

Mixed-Methods Design

A mixed-methods research design was used to determine the impact the number talks instructional strategy intervention had on my third-grade students' number sense development, mathematical proficiency, and disposition toward mathematics. A mixed-methods research design was chosen because it would allow me to collect quantitative data on students' assessment scores while also allowing for the collection of qualitative data on students perceptions, preferences, and feelings. Considering both quantitative and qualitative data would provide a better understanding of the research data (Mertler, 2014; Creswell, 2005). A triangulation mixed-methods design was used during this study as both quantitative and qualitative data were collected simultaneously and the results of all data collected were used to understand the research problem. To yield greater credibility in the overall findings, the quantitative and qualitative results were compared to see if similar results were found (Mertler, 2014).

The one-group pretest-posttest design was used to collect quantitative data to answer the first research question: What is the impact of the number talks intervention on third-grade students' number sense development and mathematical proficiency? This design was chosen because a pretest given before the introduction of the treatment allowed for some comparison to analyze the effects of the treatment. Fr this study, two quantitative assessments were used to determine if any changes had occurred after students had completed the number talks intervention for eight weeks. These assessments evaluated students current number sense development and their ability to apply conceptual understanding and numerical relationships to compute accurately, efficiently, and flexibly. More specifically, the evaluation consisted of students' ability to:

1. Solve addition, subtraction, multiplication, and division problems using algorithms;
2. Apply their understanding of place value to write equivalent expressions of a given number; and
3. Solve multiplication problems using mental computation;

The qualitative data collected during the semi-structured group interviews were categorized into three themes. These themes were (1) dispositions towards mathematics, (2) feelings about one's own math abilities, and (3) feelings about number talks.
The following sections will describe the data used to address the problem of practice.

Number Sense Classroom Assessment

The number sense pretest was teacher-created based on the math skills students' currently needed to master but had shown difficulties with based on past assessments and my observations. The pretest included ten mathematics problems that incorporated mathematics operations of addition, subtraction, multiplication, and division of various levels of difficulties. Mathematics concepts of problem-solving, multi-step problems, decomposing numbers, place value, and numerical relationships were all assessed on the pretest. Students were instructed to solve each problem to the best of their ability and show their work for each problem on this untimed assessment. Question one was a multiplication word problem, question two was a division word problem, question three was a multiplication problem involving decomposing numbers, questions four and eight were addition problems, question five was a division problem, question six was a multiplication problem involving place value, question seven was a multi-step multiplication problem, and questions nine and ten were subtraction problems. The posttest consisted of the same type of questions as the numerical values changed within each problem. However, question four on the pretest was a multi-operation problem with multiple answers to choose from. Students could use their knowledge of numerical relationships and numerical reasoning to help them solve and check any of these problems. See Appendix A and B for a copy of these assessments.

Measures of Academic Progress

At the beginning of the school year, students are administered the Measures of Academic Progress [MAP] assessments. The MAP assessment was created by the Northwest Evaluation Association [NWEA] to measure students' current knowledge in reading, mathematics, language usage, and science. This untimed, computerized assessment adjusts to students' responses to measure their performance. Student scores are measured against national norm data to identify each child's current level of proficiency, the amount of growth between testing events, and their projected proficiency (NWEA, 2017). For this particular action research study, the instructional area of Number Sense and Operations within the Measures of Academic Progress test was used to measure students' development of number sense. Within this area of the mathematics assessment, students were asked to use their understanding of numerical relationships to solve problems involving place value, counting, cardinality, addition, subtraction, multiplication, and division. After completing the Measures of Academic Progress assessment, students receive a RIT score, based on the Rasch Unit scale, which measures students' academic performance and growth over time.

Semi-Structured Group Interviews

Semi-structured group interviews were conducted throughout the eight-week intervention period. The group interviews were used to collect data on students' dispositions towards mathematics, how they perceive their math abilities, and their opinions about the number talks instructional strategy used during this study. The group interviews consisted of the teacher and students' discussion being guided by a set of four questions. See Appendix C for a copy of the interview base questions. During the group sessions, students were asked open-ended questions based on their experiences and opinions before, during, and after the number talks intervention. The open-ended questions asked during the group interviews included:

- *What are your feelings about mathematics and why?*
- *What is your opinion about number talks?*
- *If you had the choice, would you choose to continue to complete number talks in your mathematics class? Why or why not?*
- *If you could change something about number talks, what would it be? Why?*

Group interviews were chosen to collect qualitative data due to the time restraints on the day within our school schedule. Semi-structured group interviews were chosen to leave the option for follow up questions based on my students' responses.

Intervention

"Providing a class with well-designed activities and establishing a classroom environment that encourages exploration, discussion, thinking and reasoning is the best way for students to develop number sense" (Yang, 2001, p. 20). Therefore, students participated in fifteen-minute number talks during their mathematics class, three times per week for eight weeks. The number talks focused on developing students' understanding of numbers and using numbers flexibly, especially multiplication, for the support and development of number sense. I hypothesized that as students' number sense developed, their mathematical proficiency would increase and they would develop a more productive disposition towards mathematics. The number talks generally took place at the beginning of the mathematics period. During the number talks, I wrote a problem or number-of-the-day on the board. Students were then asked to solve the problem mentally, without paper and pencil. The purpose for mentally solving the problem was for the students to focus on numerical relationships to develop efficient strategies rather than focusing on standard algorithms for computation. Students were asked to solve the problem with as many strategies as they could think of. When the majority of students had demonstrated that they had found strategies to solve the problem by holding up the number of fingers that corresponded with the number of strategies they were able to use to solve the problem, the students would share their solutions to the problem and all solutions, correct and incorrect, would be recorded on the board. Students were then asked to share their computation strategies with the class while I recorded these strategies on the board and provided a visual representation, when appropriate, to help students make connections between mathematical ideas and to illustrate mathematical concepts.

During number talks that involve a number-of-the-day problem, students are asked to express that number in as many ways as possible. During some of the number talks, students were also asked to write out their strategies which would then be used as formative assessments and progress monitoring for the teacher. During the number talks, I took on the role of facilitator by prompting students and asking clarifying questions. Figure 3.1 shows three examples of number talks completed during the eight-week action research study that students' responses and solutions were recorded.

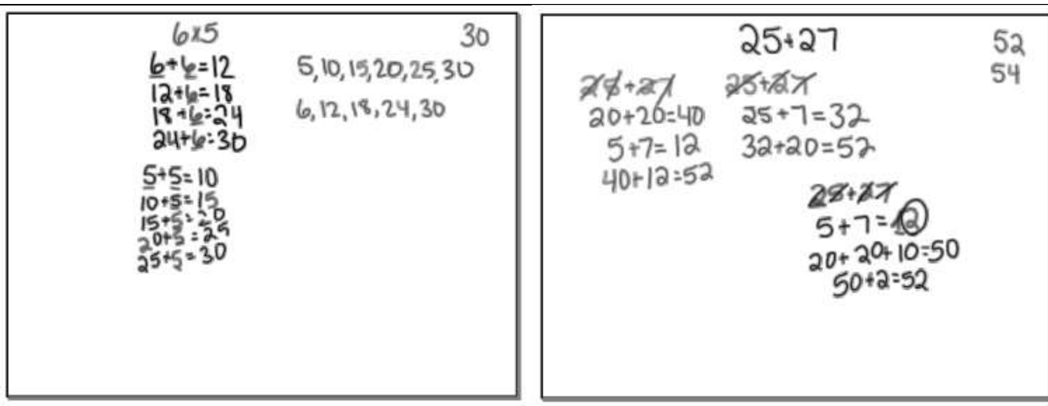

Figure 3.1. Sample Number Talks. Sample number talks recorded during this eight-week action research study.

Role of the Researcher

In action research, the teacher must critically examine their own practice and how their students learn best (Mertler, 2014). The goal of the teacher as an action researcher is to improve professional judgment and discover effective means of achieving desirable educational outcomes. To do this, the teacher must examine their practice critically and examine how their students learn best. Unlike the traditional researcher, who is typically removed from the environment and seeks to impose general findings onto a population that likely varies from the original sample, the role of the researcher in action research is a key component of the study. The teacher as researcher studies their classroom or school focusing on a particular problem, improving practice, or helping make a decision for a specific school or classroom (Mertler, 2014; McMillan, 2004).

In this action research study, I took on the role of the researcher to examine my teaching practices and aimed to collect data on how this practice affected my third-grade students' mathematical proficiency, development of number sense, and mathematical dispositions. As the teacher and researcher, I implemented the number talks instruction for all students in the study, designed one of the quantitative assessments used, and developed the base questions for and conducted the semi-structured interviews.

Action Research Validity

The validity of research data is concerned with the extent to which the data collected during the study accurately measure what they claim to measure and enables you to answer the research questions accurately (Mertler, 2014). This action research study aimed to quantitatively measure students' number sense development and athematic proficiency using the Measures of Academic Progress Number Sense and Operations assessment and a teacher-created number sense assessment. I was mainly concerned with the content validity of these two assessment instruments. Both assessments showed evidence of validity because questions on each instrument were based on content and would require students to use number sense skills to answer correctly, such as place value, cardinality, and numerical relationships. The validity of the semi-structured group interviews was also established. To do this, I triangulated the data with other data sources to make sure students' responses during the interviews were supported by other data sources. Prolonged engagement with my students also helped to validate qualitative data as I was able to develop trust with my students before interviews were conducted and had the ability to observe their patterns of behavior.

Ethical Consideration

As the chief responsibility, I ensured that this action research study adhered to ethical standards related to the treatment of students and their data (Mertler, 2014). Before collecting data for this action research study, parental consent from the parents of all students was obtained requesting permission for students to participate in the study because all participants were under the age of eighteen and were not of legal age to give their consent (Mertler, 2014). See Appendix D for a copy of the consent form. I also obtained assent from students noting their agreement to participate in this action research study. See Appendix E for a copy of this form.

Following Mertler's (2014) suggestion, my students and their parents were given the following information:

1. A description of the research topic and research study;
2. A description of what participation would involve;
3. An indication that participation is voluntary and that it can be terminated at any time without penalty;
4. A guarantee of confidentiality and anonymity;
5. An offer to provide a summary of the findings to participants (p. 108)

To ensure privacy and anonymity in this study, I changed the name of the research site and students.

In adherence to ethical considerations, this action research study is authentic, honest, and beneficial (Mertler, 2014).

Research Context

This action research study was conducted at Junior Elementary School in Columbia, South Carolina. This suburban elementary school serves 579 child-development through fifth-grade students. Because over 40 percent of students at this school come from low-income families, the school receives Title I financial funding (South Carolina Department of Education, 2017). At Junior Elementary School all first through fifth-grade students were assessed in mathematics at the beginning of the 2017-2018 school year using the Measures of Academic Progress assessment. Of the 77 third-grade students, 17% scored on the level of "High" or above the 81st percentile, 22% scored on the level of "High/Average" or between the 61st and 80th percentiles, 17% scored on the level of "Average" or between the 41st and 60th percentiles, 26% scored on the level of "Low/Average" or between the 21st and 40th percentiles, and 18% scored on the level of "Low" or below the 21st percentile on the mathematics Measures of Academic Progress assessment. The Measures of Academic Progress mathematics assessment is also subdivided into mathematical skills. Table 3.1 shows the percent of all third-graders at Junior Elementary School that scored within each percentile range on the instructional area of Number Sense and Operations on the Measures of Academic Progress mathematics assessment administered in the fall of the 2017-2018 school year.

Table 3.1: Number Sense and Operations Percentiles for Third-graders

The percent of third–graders at Junior Elementary School scoring in each percentile range on MAP Number Sense and Operations instructional area.

Number Sense and Operations Percentiles

Low <21st percentile	Low/Average 21-40 percentile	Average 41-60 percentile	High/Average 61-80 percentile	High >80th percentile
19%	17%	29%	30%	5%

Teacher

As the teacher for this group of third-grade students, I took on the role of teacher and researcher for the current action research study. The problem of practice I had is that a majority of my students struggled to problem solve because they struggled to understand mathematical concepts and work flexibly with numbers. Instead, my third-grade students tended to try to use standard mathematical algorithms for all problems when there were more appropriate and efficient problem-solving strategies available. I used this action research study to investigate my teaching strategies by incorporating the number talks teaching strategy into my mathematics instruction. I intended to use this action research to explore how the use of the number talks strategy affected the development of number sense, mathematical proficiency, and the dispositions toward mathematics of my third-grade students.

Students

The students that participated in this action research study consisted of 20 students from my third-grade math class at Junior Elementary School. This class includes 40% girls and 60% boys of which 80% are African American, 5% are Caucasian, 10% represent two races, and 5% are Hispanic students. Of the 20 students in the class, 55% of students scored on the level of "Low/Average", 25% of students scored at the level of "Average", and 20% of students scored at the level of "High/Average" as indicated by the 2017 Fall scores on the Measures of Academic Progress mathematics assessment. Table 3.2 shows the scores of these students on the instructional area of Number Sense and Operations on the Measures of Academic Progress mathematics assessment administered in the fall of the 2017-2018 school year.

Table 3.2: Number Sense and Operations Percentiles for Participants

The percent of third–graders at Junior Elementary School scoring in each category on MAP Number Sense and Operations instructional area.

Number Sense and Operations Percentiles

Low <21st percentile	Low/Average 21-40 percentile	Average 41-60 percentile	High/Average 61-80 percentile	High >80th percentile
0%	40%	35%	25%	0%

As the population of students in the third-grade becomes more and more diverse each year, I need to be prepared to work with all students effectively. It is important to build on students' cultural backgrounds to meet their needs. Teachers need to be aware of the relationship between culture and learning and how the mathematics classroom can support or constrain different forms of knowledge (Gutierrez, 2013; Nasir & Cobb, 2007; White et al., 2016). According to Thornton (2006), it is critically important for a mathematics teacher to develop a multicultural knowledge base that will affect the decision making in their classroom. This knowledge will affect teacher decision making, practices, and effectiveness. This includes the understanding and acceptance of how one's culture affects the perception of teaching, learning and doing mathematics (White et. al, 2016). It is imperative that the teaching strategies used in my classroom match the learning needs of my students.

Conclusion

During this action research study, a mixed-methods design was used to examine the impact of the number talks instructional strategy on students in one third-grade mathematics class. A one-group pretest-posttest design was used to collect data on any changes that may have occurred due to the number talks intervention. Changes in students' number sense development, changes in students' mathematical proficiency, and changes in students' dispositions toward mathematics were all analyzed. Quantitative data collection instruments included a teacher-created number sense assessment and the Number Sense and Operations instructional area of the Measures of Academic Progress assessment. The qualitative instrument used in this study was a semi-structured group interview. Student participated in number talks that lasted 15 minutes each session for three days per week during the intervention period of this eight-week study. During these number talks, students completed mathematics problems, mentally, then shared and justified the computation strategies they used. This strategy built on and developed a greater conceptual understanding, understanding of numerical relationships, and students were able to develop computational strategies that they could use flexibly to solve problems. The results of this study are reported in chapter four.

CHAPTER 4: FINDINGS AND INTERPRETATION OF RESULTS

Introduction

Chapter four examines the implementation and impact of an eight-week number talks intervention on the students in my third-grade mathematics class. The problem of practice for this action research study was that the current group of students struggled to understand math algorithms and relationships between numbers completely. This struggle to understand algorithms led to students' increasing difficulties with applying these algorithms in new situations and with higher level mathematics problems. The types of problems my students tended to struggle with were problems involving larger numbers, multi-step problems, and multiple operations problems. This is the area I chose to focus on because all of the above-mentioned skills are required for third-grade students to master according to South Carolina mathematics curriculum standards. When these skills are not mastered, they have a lingering effect on students throughout adulthood. These struggles affect students' mathematical proficiency and their dispositions towards mathematics. In order for students to be successful in solving multi-step problems and multi-operation problems, they must first be successful in foundational skills (Parrish, 2010). The lack of student proficiency in basic math facts often contributes to future difficulties in understanding and performing more complex multi-step mathematics problems as students reach higher math curriculum (Boychuk & Cui, 2014).

As the researcher and teacher, my goal was to develop my third-grade students' number sense so that they may gain mathematical proficiency. As students develop number sense, they no longer have to rely on their memorization of algorithms and facts, but learn to use relationships between numbers and their own understanding of mathematical processes to solve problems. According to Parrish (2010), for students to gain mathematical proficiency they must be given the opportunity to "grapple with number relationships, apply these relationships to computation strategies, and discuss and analyze their reasoning. To determine effective strategies to increase my students' number senses development and mathematical proficiency, I chose to investigate the use of number talks among third-grade students.

Research Questions

This action research study was guided by the following research questions:

1. *What is the impact of the number talks intervention on third-grade students' number sense development and mathematical proficiency?*
2. *What is the impact of the number talks intervention on third-grade students' dispositions towards mathematics?*

Findings of the Study

The results of this action research study are presented in two categories of quantitative data along with the thematic results derived from qualitative data. In the first section, data is presented from the teacher-created number sense classroom assessment. In the second section, data are presented from the Number Sense and Operations instructional area of the Measures of Academic Progress [MAP] assessment to measure students' current level of number sense development and understanding. Data collected from these two assessments were then triangulated and analyzed. The triangulation was used to validate the data by showing that each data collection instrument tended to agree with each other or do not directly contradict each other. Both sets of data were collected based on the one-group pretest-posttest methodology. Before the eight-week intervention, students were given both untimed assessments on different dates. After the eight-week intervention, students were then given the post assessments which mirrored the pretests. In the final section, I present results from the qualitative data collected during the semi-structured group interviews. Qualitative data was used to get a deeper understanding of students' development of number sense and their current thoughts and feelings about mathematics and number talks.

Number Sense Classroom Assessment

At the start of the eight-week study, students were given a teacher-created pretest used to measure students' understanding of numbers and concepts and to measure their ability to use their understanding to work with numbers in flexible ways, also known as number sense. Using this assessment, my goal was to determine students' current level of number sense development. I examined whether students used the most accurate and the most efficient strategies to solve problems on this assessment. This would reveal students' understanding of numbers and their relationships. The pretest consisted of ten mathematics questions with a mixture of addition, subtraction, multiplication, and division operations on various levels of difficulties. Included in the pretest were one multiple choice question, eight open response questions, and one fill in the blank question. The skills assessed on the pretest were skills that although previously taught, students continued to show a deficit in those areas. The posttest was formatted similarly to the pretest while the numbers used within each mathematics problem were changed. The posttest was administered after the eight-week number talks intervention.

On the number sense classroom pretest taken by 20 students, students scored an average of 53% out of 100%. The scores on this pretest ranged from 30% to 90%. Students were not given a time limit to complete the test nor were any instructions given on how to complete the test. The mean score for the number sense classroom posttest was 66.3% out of 100%. The students' assessment average went up 13.3 points after the number talks intervention which is a 25 percent gain. Compared to the scores the 20 students received on the number sense classroom pretest, one student went down 10 percentage points, four students had no change in score, one student went up five percentage points, four students went up 10 percentage points, two students went up 15 percentage points, five students went up 20 percentage points, two students went up 30 percentage points, and one student went up 40 percentage points.

On this assessment, questions on the pretest were matched to a question on the posttest to assess similar skills. This is true for all questions except for number four. This question was a three-digit addition problem on the pretest, but a multi-step problem on the posttest. The reason this question was changed on the posttest was that the majority of students had mastered the concept of multi-digit addition and did not show any difficulties with the concept during our class number talks. Geneva, one of the students that made no gains between test events missed the same types of questions on both tests. Geneva did, however, show a better understanding of the math processes needed to solve each problem. For example, on the multiplication word problem, she drew an array to solve the problem and solved it incorrectly. On the posttest, she wrote and solved three multiplication problems in an attempt to answer the question, but used one wrong factor in two of the problems, causing her to get an incorrect solution to the problem. Jackson was another student who did not make any gains. He tended to struggle on the word problems. On the division word problem on the pretest, he correctly drew an array and solved the problem, but on the posttest, he did not draw an array and answered the problem incorrectly. Both Dorothy and Kyle, who made no gains, answered the same questions incorrectly on the pretest as they did on the posttest. Matt was the only student that performed better on the pretest than on the posttest. On the pretest, he answered, correctly, the two-digit addition, two-digit subtraction, and the three-digit subtraction problems. On the posttest, Matt answered the two-digit addition and the base-ten multiplication problem correctly. Figure 4.1 shows the item analysis of the pre and post administration of the number sense classroom assessment. As the graph indicates, based on the number of students that answered each question incorrectly, students continue to struggle with decomposing multiplication problems, which relates to numerical relationships, and solving multi-step equations. This is indicated by a significant portion of students answering questions three and seven incorrectly. On the posttest, some students were able to identify and solve the appropriate multiplication equations but failed to complete the second step of finding the sum of the products when answering question seven, the multi-step problem.

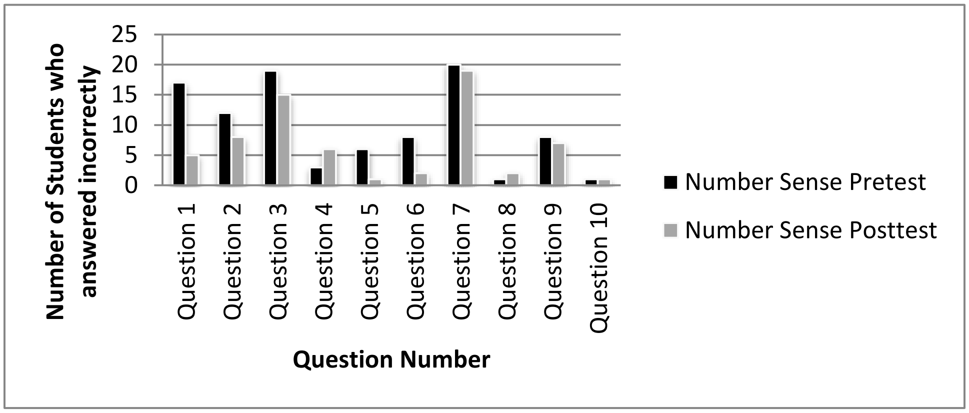

Figure 4.1: Number Sense Classroom Assessment Question Analysis. Question analysis of the number of students who answer questions incorrectly on the number sense classroom assessment.

Before receiving the eight-week number talks intervention, 40% of the 20 students in this action research study scored higher than 50% out of 100%. After participating in number talks for three days per week for eight weeks, the percentage of students who scored higher than 50% on the number sense classroom assessment rose to 80% of the students. Figure 4.2 shows the number of students who scored within each percentage range on the number sense classroom pretest as compared to the posttest.

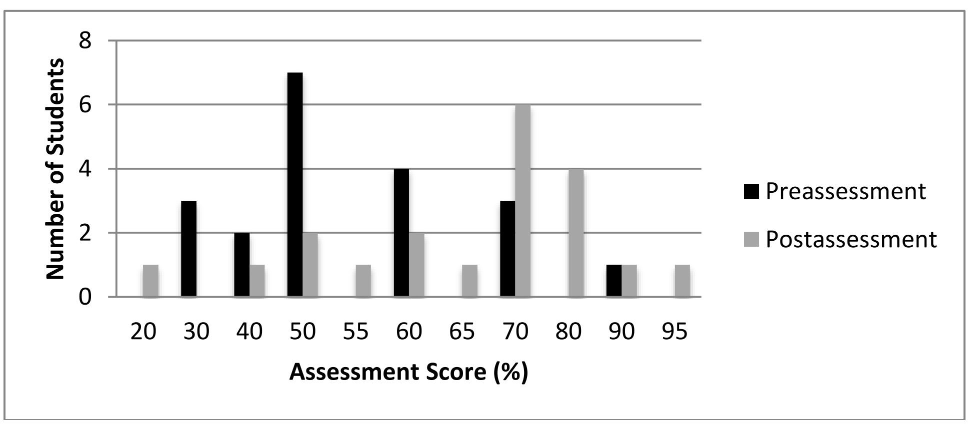

Figure 4.2: Number Sense Classroom Assessment Data. Students' overall assessment scores on the number sense classroom pre-assessment compared to the post-assessment.

On average, students also took less time to complete the posttest then they did with the pretest. For example, Denise took 75 minutes over three class periods to take the pretest and Tim took 90 minutes over three class periods to complete the pretest. For the posttest, Denise took 60 minutes and Tim took 75 minutes to complete the same number of problems. Table 4.1 shows data comparing students' scores on the number sense classroom pre-assessment compared to the post-assessment.

Table 4.1: Number Sense Classroom Assessment Data
Number sense classroom assessment data

Student	Pretest (%)	Posttest (%)	Change (Points)
1	40	40	0
2	50	50	0
3	40	55	15
4	60	80	20
5	50	70	20
6	50	50	0
7	90	95	5
8	70	90	20
9	50	70	20
10	70	70	0
11	70	80	10
12	60	70	10
13	60	80	20
14	30	70	40
15	50	65	15
16	30	60	30
17	30	20	-10
18	50	80	30
19	60	70	10
20	50	60	10
Mean	53	66.25	13.25
Median	50	70	12.5
Standard Deviation	15.25	17.46	
Min	30	20	-10
Max	90	95	40
Range	60	75	50

Measures of Academic Progress

The MAP assessment was administered before and after the intervention period of this study. To answer the quantitative research question, only data from the Number Sense and Operations instructional area of the math MAP assessment was analyzed. Of the 20 students in this study, 96 percent increased their Number Sense and Operations score after completing the number talks intervention. According to national norms, the average third-grader is projected to increase 11 to 14 points in score between the Fall and Spring testing events (NWEA, 2015). In this study, 75 percent of students' met this growth or higher on the Number Sense and Operations instructional area as indicated in Figure 4.3. According to national norm-referenced data, the average RIT score for third-grade students who completed the Number Sense and Operations unit at the beginning of the year is 180-199. The average score for students who participated in this study was 188.55 with the minimum score being 179 and the maximum score being 201 during this same period. The average score for third-grade students who take this assessment in the Spring is 193-211. The average Spring score for students in this study was 201.55 with the minimum score being 186 and the maximum score was 217. On the Fall pretest, Crystal was the only student that scored below the national average, but on the posttest, she increased her score by 20 points to 199 and within range of the national average. Michael was the only student in the study that scored above the national norm on the pretest but also was the only student to decrease in score. However, he did remain with the average range for the posttest. On the posttest, Dorothy, Mitch, and Amy fell below the third-grade average and Josh, Kevin, and Gloria scored above the norm average.

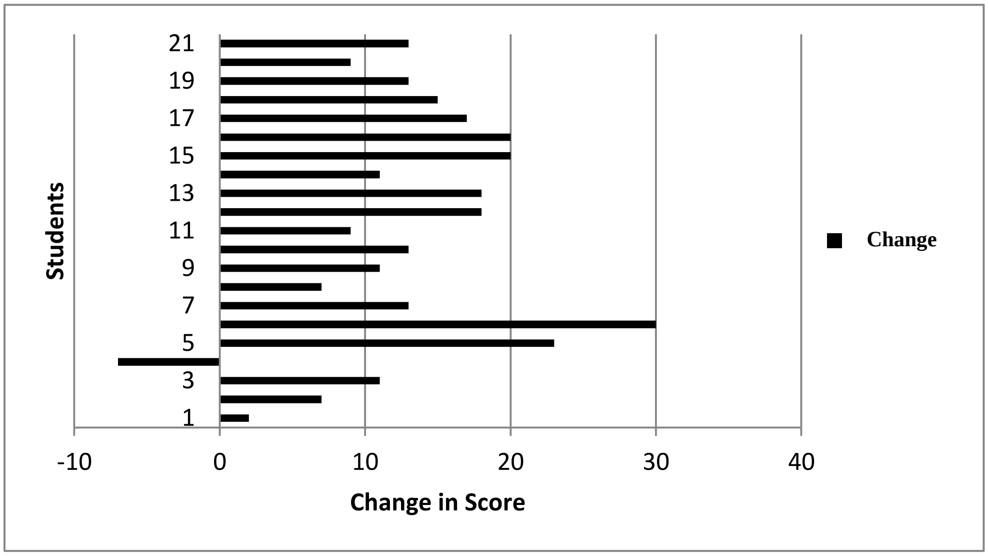

Figure 4.3: Number Sense and Operations MAP Test Events Differences.

Figure 4.4 and Table 4.2 show the pre and post RIT scores of each student on the Number Sense and Operations instructional area on the MAP assessment. Overall the average point growth on the Numbers and Operations area of the MAP assessment for students who participated in this action research study was 13 points.

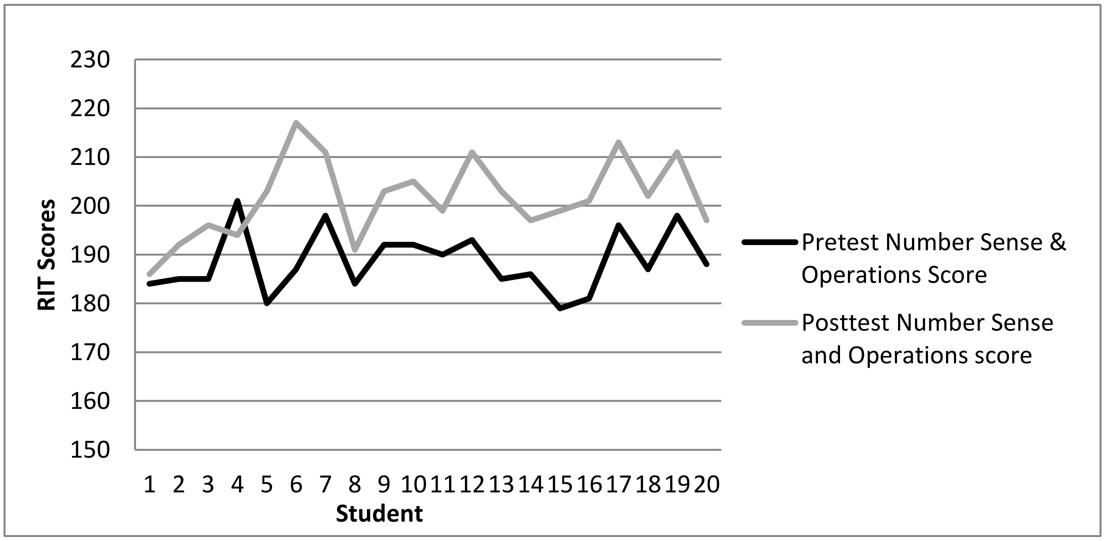

Figure 4.4: Number Sense and Operations MAP RIT Scores. The pre and post RIT scores of each student on the Number Sense and Operations instructional area on the Measures of Academic Progress assessment.

Table 4. 2: Number Sense and Operations MAP Assessment Data

Pretest and posttest student data from the Measures of Academic Progress [MAP] instructional area of Number Sense and Operations.

Student	MAP Pretest (%)	MAP Posttest (%)	Change (Points)
1	188	197	9
2	184	186	2
3	185	192	7
4	185	196	11
5	201	194	-7
6	180	203	23
7	187	217	30
8	198	211	13
9	184	191	7
10	192	203	11
11	192	205	13
12	190	199	9
13	193	211	18
14	185	203	18
15	186	197	11
16	179	199	20
17	181	201	20
18	196	213	17
19	187	202	15
20	198	211	13
Mean	188.55	201.55	13
Median	187	201.50	13
Standard Deviation	6.27	8.09	
Min.	179	186	179
Max	201	217	201
Range	22	31	22

Semi-Structured Group Interviews

There was much agreement among students about their experiences and opinions about mathematics and the number talks intervention throughout this action research study. Many students expressed that they found difficulty in working with multiple numbers when solving mathematics problems before being exposed to number talks. When asked about her experiences with mathematics before participating in the number talks intervention during this action research study, Gloria expressed, "I think it is confusing because we have to add a bunch of numbers up at the same time." Similarly, Geneva stated, "I think it is really hard because it is a lot of numbers and I cannot do all those numbers." Christopher simply stated, "I don't like it." After further prompting to explain his answer, he detailed his dislike for, "adding all the numbers." In contrast to many other participants, Harry expressed liking mathematics. This student stated, "I think multiplication is easy because multiplication, I am good at. Division, I am not good at."

I also asked students about their opinions and experiences with the number talks intervention. Responses from students showed that they felt more comfortable working with numbers after participating in the intervention. Michael reflected on his experiences when we first began incorporating number talks in the mathematics lessons compared to how he felt at the end of the eight-week intervention. "I thought this was going to be a normal math class, but now I learn math much better!" Michael also said, "At first I thought it was going to be hard, but now I'm used to it. Learning the strategies made it not so hard." Although Michael seemed to feel more confident in his math ability, he was the only student in the study to score greater on the MAP pretest than on the posttest. However, he did score 20 points higher on the number sense classroom posttest than on the pretest. This inconsistency may be due to students being exposed to more difficult problems on the MAP assessment. Neither our classroom number talks nor the number sense classroom assessment included fractions and decimals which both may have been included on the MAP assessment. Dorothy reflected on how her feelings about number talks changed throughout the eight-week intervention. She stated, “At first it was kind of hard, but when we started practicing more on it, it made sense, and it helped me with my addition problems that were hard at first.” Students also recognized and appreciated the benefit of learning from their classmates. Gloria realized the benefits of hearing strategies used by her classmates and incorporated those strategies when developing her sense of numbers and how she would choose to solve problems. She stated, “When I heard the different examples, it helped me with my addition, and I caught on to them.”

Finally, the majority of students agreed that they would like to continue to have number talks in their mathematics class both for the remainder of the school year and in their future classes. Matt, the one student who scored higher on his number sense classroom pretest by 10 points, said he would not want to participate in number talks in the future, but did not elaborate on his response when prompted. Students expressed they would like to work more on division, area, and perimeter problems as those were their concerns and felt that number talks would help them to solve these types of problems better.

Interpretation of Results of the Study

A mixed-methods design was used during this action research study to answer the research questions. The students of this study were my 20 mathematics students and were given pretests and posttests to determine the effectiveness of the intervention used in this study. The following section will consist of an interpretation of the previously reported findings of this study.

Number Sense Classroom Assessment

To determine students' current levels of number sense, I assessed 20 students using researcher-created tests. On the number sense classroom assessment, the mean score on the pretest was 53% out of 100% and the mean score on the posttest was 66.6%. The 13.6 percentage point increase suggests that students did benefit from the number talks intervention throughout the eight-week action research period. A mean score of 66.6% shows that students were able to apply what they had learned during number talks to correctly answer an increased number of math problems on the posttest. On this assessment, students also demonstrated a better understanding of number sense and the ability to work with numbers more flexibly in how they solved problems on the posttest compared to the pretest. Students demonstrated their ability to work flexibly with numbers by varying the strategies they chose to solve problems based on their knowledge and understanding of number relationships. Figure 4.5 shows Denise's pretest assessment compared to her posttest assessment and how similar problems were solved before and after the eight-week number talks intervention. The figure shows during the posttest, Denise used a much more efficient solution to solving the math problem.

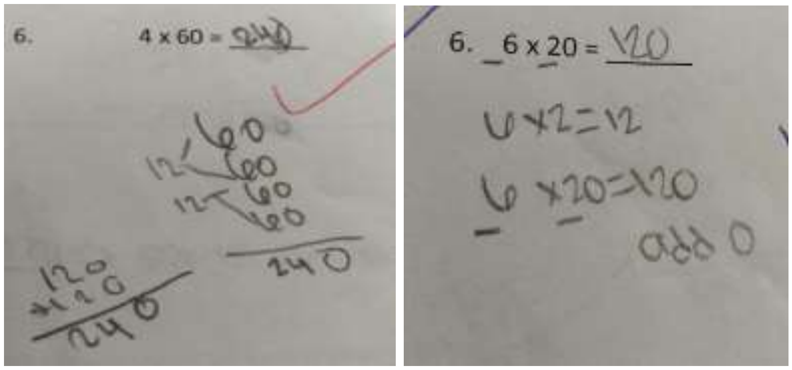

Figure 4.5: Number Sense Classroom Assessment Student Example One. Student work for the number sense classroom pretest on the left and posttest on the right.

In Figure 4.6, Amy is solving a multiplication problem. During the pretest, she tried solving the problem, unsuccessfully, by drawing an array. An array can be beneficial when first understanding the process of multiplication, but is very tedious. On the posttest, Amy identified multiplication equations that could be used to solve the problem and solved the equations mentally. This strategy is much more efficient than the strategy she used during the pretest and led her to the correct solution.

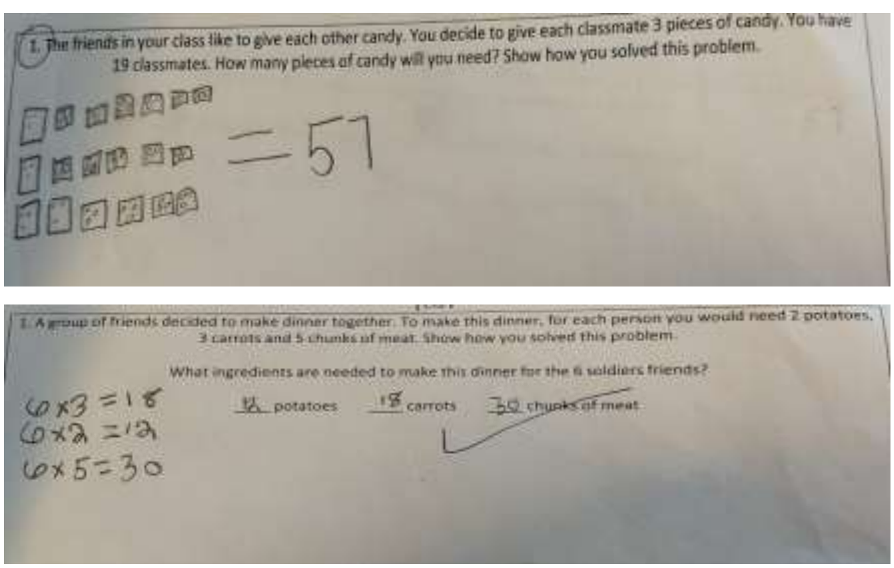

Figure 4.6: Number Sense Classroom Assessment Student Example Two. Student work for the number sense classroom pretest on the top and posttest on the bottom.

Measures of Academic Progress Assessment

The 20 students in this action research study were administered the Measures of Academic Achievement assessment prior to participating in the number talks intervention and at the completion of the number talks intervention. This assessment was given to measure students' current level of number sense development and their ability to use number sense to solve math problems. Figure 4.7 presents the students' results of the pre and post Number Sense and Operations instructional area on the Measures of Academic Achievement assessment. As reflected in the graph, students performed better on the assessment given after the number talks intervention and were able to increase the group's mean score by 13 points. In fact, 15 percent of students in this study scored above the national norm and 45 percent of students made greater growth than the norm-referenced data suggest typical third-graders make. The graph indicates that this group of third-grade students did benefit from the use of number talks during their mathematics instruction and shows that this eight-week intervention did help to increase students' number sense development and their ability to work with numbers more flexibly by using efficient strategies to problem solve throughout the assessment.

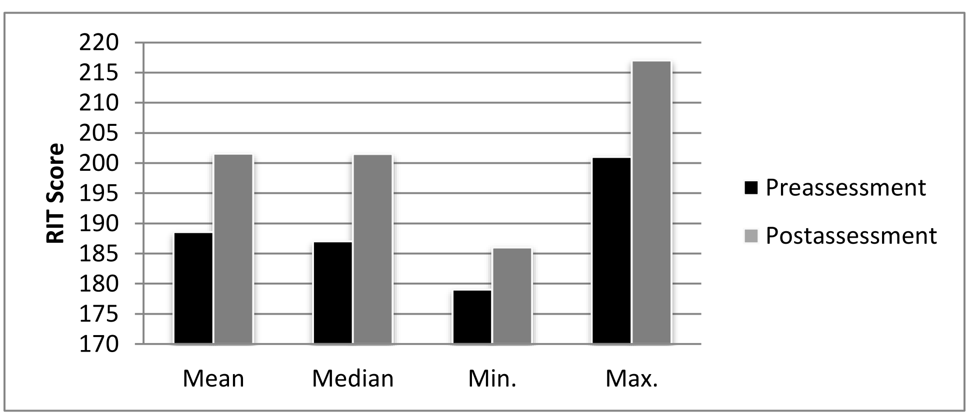

Figure 4.7: Number Sense and Operations MAP Group Data. This graph shows data from the pre and post assessments.

Semi-Structured Group Interviews

Group interviews were conducted before and after the number talks intervention. The results of the interviews suggest that the number talks intervention had a positive impact on students' dispositions towards mathematics and students had a more productive disposition toward mathematics after participating in the number talks. A productive disposition towards mathematics means that students see sense in mathematics and see themselves as effective learners and doers of mathematics (National Research Council, 2001). After the intervention, students expressed many positive comments about mathematics. Denise stated, "It made sense when we were going through the problems." Michael expressed more confidence in his mathematics abilities by stating, "Now I learn [math] much better." Finally, Gloria expressed being able to catch on to mathematics strategies much easier after participating in number talks.

Conclusion

My third-grade class was assessed using teacher-created number sense pre and post-tests, the Measures of Academic Progress math assessments, and semi-structured group interviews to determine the impact the number talks intervention had on their development of number sense, their mathematical proficiency, and their dispositions towards mathematics. This one-group pretest-posttest action research study occurred over an eight-week period with interventions taking place three days per week. The data on the number sense classroom assessment and the Measures of Academic Progress assessments both showed an increase in the mean scores of students from the pretest to the posttest. The results also showed that students were able to think more flexibly about numbers and number relationships to use more efficient strategies when computing after the intervention. The results indicate that there was a positive relationship between the number talks intervention and students' ability to work with numbers more accurately, efficiently, and flexibly, as well as become more mathematically proficient due to their increase in understanding of mathematical concepts. Statements made during semi-structured group interviews also revealed that the number talks intervention positively influenced students' attitudes about mathematics and how they thought about and worked with numbers. Students now felt that mathematics and the computation strategies made sense and they felt more confident in their ability to accurately solve mathematics problems. In relation to the research questions that guided this action research study, the findings suggest that the number talks instructional strategy had a positive effect on these third-grade students in their development of number sense, in their increase in mathematical proficiency, and helping them to develop a more productive disposition towards mathematics.

CHAPTER 5: SUMMARY AND DISCUSSION

Introduction

This action research study followed a mixed-methods design to investigate the impact the number talks intervention had on third-grade students' number sense development, mathematical proficiency, and dispositions towards mathematics. Following the one-group pretest-posttest research design, prior to participating in the eight-week study students were given the Measures of Academic Progress mathematics assessment. The results from the Number Sense and Operations instructional area of the MAP assessment were used to determine students' current level of number sense development. A number sense pretest was also created to determine students' current math ability and number sense development. This assessment was also used to assess students' ability to efficiently and flexibly choose computation strategies. To determine students' current dispositions towards mathematics, I conducted semi-structured group interviews. The same data collection methods were done following the number talks intervention period.

During the acting phase of this action research cycle, the number talks intervention was conducted three days per week for 15 minutes each session. Students were asked to solve math problems using mental math and then share their method of problem-solving. Data were collected during this action research study, and the results were analyzed. Based on the results, I conclude that the use of number talks with this third-grade class showed to help in the development of number sense, to enhance the students' abilities to problem solve, and to create more positive emotions and feelings toward mathematics for these students.

Research Questions

This action research study was guided by the following research questions:

1. *What is the impact of the number talks intervention on third-grade students' number sense development and mathematical proficiency?*
2. *What is the impact of the number talks intervention on third-grade students' dispositions towards mathematics?*

Focus of the Study

As I saw that students in my third-grade class showed complications in solving increasingly difficult math problems such as those involving multiple steps or multiple operations, I sought to find an intervention that would help students to complete these computations. The focus of this study was to determine whether the number talks intervention could assist me in developing number sense in my current third-grade mathematics students. I also strived to improve students' abilities to problem solve more complex computations by increasing their mathematical proficiency and dispositions. I investigated the use of number talks because research shows number talks would give students the ability to not only more effectively and more logically solve problems for themselves, but also learn from their peers as solutions and methods were explained by other students.

Overview/Summary of the Study

The purpose of this study was to identify the impact the number talks intervention would have on my third-grade students' number sense, mathematical proficiency, and the development of a more productive disposition towards mathematics. The problem of practice for this study was the number of students within my third-grade class that struggled to solve mathematics problems accurately, flexibly, and efficiently. The students were relying on one or two standard algorithms to solve math problems that could be solved more efficiently using a variety of other strategies. My students lacked computational understanding, lacked in an understanding of numerical relationships, and therefore lacked the ability to look at and work with numbers flexibly. This led me to investigate number sense and how developing number sense could help students demonstrate more success in their current math class and into adulthood. I also examined how that success could lead to a more productive disposition towards mathematics. Chapter two of this study identifies the pedagogy behind mathematics and number sense and shares the findings of previous studies that focused on number talks and number sense. Chapter two also explains the theoretical and historical basis for this action research study. Chapter three describes the action research methodology used and describes the participants of the study. Chapter four describes the study results. Chapter five will describe the implications of this study and recommendations for future studies.

Discussion of Major Points of the Study

Quantitative and qualitative data were collected to determine the impact the eight-week number talks intervention would have on my third-grade students' number sense development, math proficiency, and their feelings about mathematics. The Number Sense and Operations area of the MAP assessment and a teacher-created number sense assessment was used to assess students' progress. Semi-structured group interviews were also utilized to gain insight into students' thoughts about mathematics and the intervention. Assessments designed for this study are described in detail in chapter three.

Number Sense Classroom Assessment

The number sense assessment designed for this study was used to not only identify students who could answer these math problems correctly, but also to identify if students were using their number sense to find the most efficient and accurate ways to compute problems. Figure 5.1 shows an example of Harry's change in efficiency when solving a division equation. Figure 5.2 shows Lauren using different strategies to solve a division word problem. These findings indicate that the number talks intervention was effective in helping to develop students' number sense as students showed greater knowledge of numerical relationships and using more efficient strategies to solve problems on the posttest than used on the pretest. Students also showed growth in mathematical proficiency with a mean score of 66.75 out of 100 after the intervention compared to 53% prior to the number talks intervention.

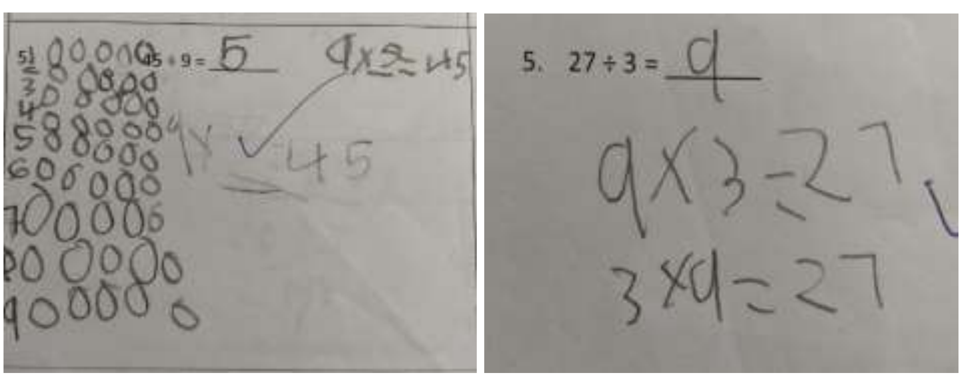

Figure 5.1: Number Sense Classroom Assessment Student Example Three. Student work for the number sense classroom pretest on the left and posttest on the right.

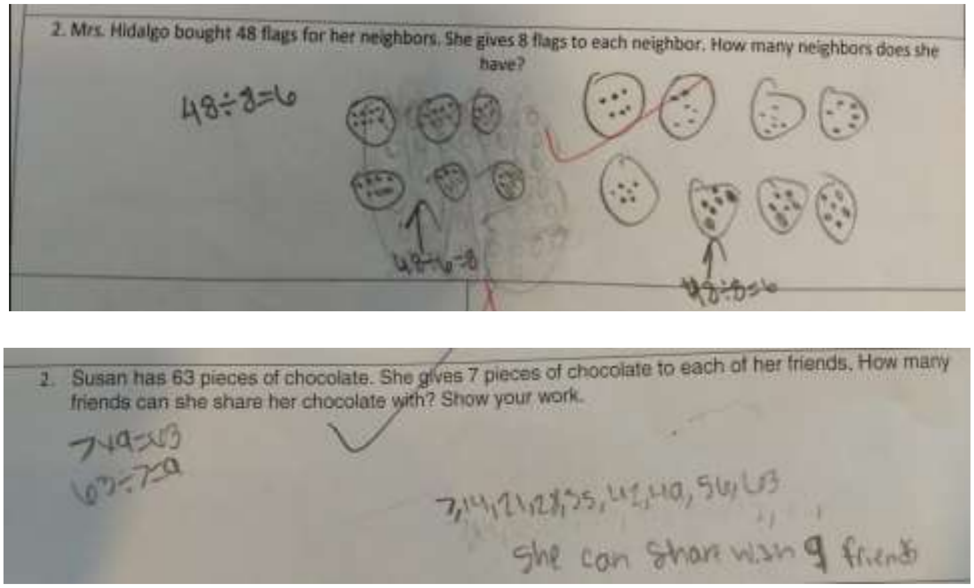

Figure 5.2: Number Sense Classroom Assessment Student Example Four. Student work for the number sense classroom pretest on the top and posttest on the bottom.

Measures of Academic Progress Assessment

On the Number Sense and Operations area of the MAP assessment, data was not able to be collected on how students solved problems. Instead, data on students' number sense development was based on their ability to correctly answer questions requiring skills in the area of place value, base ten, counting, and cardinality. On this assessment, 95% of students increased their score by two or more points as compared to the pretest. The mean score for the group also rose from 188.55 before the number talks intervention to 201.55 after the intervention. This data is significant because it shows that students were able to apply their number sense to more accurately answer these Number Sense and Operations questions than they previously could.

Semi-Structured Group Interviews

I collected qualitative data by conducting semi-structured group interviews with students. Analysis of students' responses during the interviews revealed important patterns among students who participated in the eight-week action research study. Students revealed that although they were intimidated by working with equations that involved multiple or larger numbers before the intervention, by the end of the intervention, they felt more comfortable working with these types of math problems. Students also recognized the benefits of learning from their classmates as they shared various solutions they used to solve the problems they were presented.

The three forms of data collected during this action research allowed me to determine that conducting number talks during this third-grade math class had a positive impact on students' number sense, mathematical proficiency, and dispositions towards mathematics.

Action Plan: Implications of the Findings

The purpose of action research is to be able to study your own students and your instructional practices in order to improve the quality and effectiveness of your classroom (Mertler, 2014). As I studied the use of number talks to increase my third-grade students' number sense, I did clearly see the effectiveness of this intervention. I saw the increase in confidence in their mathematics abilities and each student's development in understanding and use of a range of effective strategies that helped them to more accurately and flexibly solve equations.

After analyzing the qualitative and quantitative data, I found that the number talks did need to be expanded to cover more math skills. Students expressed not feeling as confident in their ability to solve math problems involving skills we did not cover during our number talks. In future cycles of this action research study, I would collect more formative data to be used to enhance the number talks' discussions and the skills reviewed during number talks. In preparation for this current study, the number talks were designed before the study began. In looking at the summative data and listening to students' comments during the group interviews, I realized pre-planning the number talks was a mistake. The number talks should have been more closely based on students' needs as they developed throughout the study. Formative assessments should have been given at least every two weeks, and the number talks should have been based on these results. The number talks also should have reflected a greater variety of skills. Students would have benefited more if more complex skills were highlighted throughout the weeks of this action research study. Students would be able to grapple with, apply strategies, discuss, and analyze many more math concepts.

Suggestions for Future Research

Action research is meant to be cyclical. Therefore, the next cycle of this study will take place during the upcoming school year. This action research study will be expanded to be implemented in every third-grade mathematics class at Junior Elementary School. The third-grade teachers will participate in professional development to implement daily number talks throughout the school year. After data has been collected and analyzed for the second cycle of this action research study, findings will be shared with all faculty members at Junior Elementary school. Teachers will be encouraged to implement the number talks strategy into their math classes.

I found that I was not able to cover many different skills when I implemented number talks only three days per week, so future researchers are recommended to increase the number of days number talks are implemented in their math class. It is also suggested that future researchers frequently formatively assess their students to develop number talks that are adaptive to students' needs to more effectively assist in enhancing their learning.

The current action research study was conducted on one third-grade class. Future research would benefit by expanding the study to include a greater number of participants. Future research could include more third-grade students as suggested by the next cycle of this action research study or students in other grade levels. Future research would also benefit from including more educators in the study. Number talks are facilitated by the teacher. Therefore the way the number talks are conducted may have an impact on student learning and should be noted. Because students of different backgrounds learn differently and benefit from different types of instruction, future research should include a greater variety of student backgrounds. Students should come from different races, socio-economic backgrounds, and levels of math ability to identify if number talks affect different types of students differently.

Finally, future action research studies would benefit from an explanatory mixed-methods design. This design would allow the researcher to get a better understanding of students' reasoning and understanding of mathematics' skills and concepts. The researcher would be able to use qualitative data to explain and make sense of the quantitative data. Knowing why students chose particular strategies during their assessments would greatly increase the researcher's understanding of the influence number talks had on students' number sense development and mathematical proficiency. To collect this data, the teacher should conduct individual and group. Qualitative data may have been hindered during this study because some students were influenced by their peers' comments and some students may not have felt as comfortable sharing their true feelings within the group setting.

Benefits to Educators

Students have different learning styles and ways they learn best. In a classroom of 25 students, it is difficult for a teacher to teach in a way that all students understand. Number talks give students the opportunity to learn from their classmates. Students see and hear different computation strategies their classmates find beneficial and can add these strategies to their math toolkits. Some strategies students have found most helpful could be ones the teacher had never taught or ones a student did not understand the first time it was taught and now grasps the concept when explained by a peer. Students' sharing their strategies must explain the process step-by-step. This discourse helps the student to get a better conceptual understanding of the strategies they are using and why they work.

Students do not only benefit when a classmate answers a problem correctly, but incorrect answers give the teacher the opportunity to address misconceptions and identify concepts that need to be retaught during the regular math lesson. I found there were many benefits to incorporating the number talks strategy into my third-grade class. Based on the findings of this actions research study, research on number talks, and research on number sense development, I believe being educated on number sense and its benefits, how number talks enhance number sense, and being trained on how to conduct number talks in their own classroom would benefit teachers and students of all ages.

Conclusion

The current action research study intended to identify if the number talks intervention would be beneficial in helping students develop number sense. Number sense allows students to increase their knowledge and understanding of numbers to gain more efficiency in identifying and using the most appropriate strategies when solving mathematics problems (Boaler, 2015). The findings of this study indicated that this group of third-grade students did benefit from the use of number talks in increasing their mathematical proficiency, increasing their knowledge of effective math strategies, and building their confidence in their math abilities. Analysis of the data shows number talks may have a positive impact on other students' number sense development as well. This action research study has allowed me to see the positive impact number talks has on students and affirms the need for me to continue to practice this method of teaching into the next school year and share with other educators.

REFERENCES

Alsawaie, O. N. (2012). Number sense-based strategies used by high-achieving sixth grade students who experienced reform textbooks. *International Journal of Science and Mathematics Education, 10*(5), 1071-1097.

American Association of University Women. (1992). *How schools shortchange girls.* Washington, D.C.:AAUW Educational Foundation.

Andrews, P., & Sayers, J. (2015). Identifying opportunities for grade one children to acquire foundational number sense: developing a framework for cross cultural classroom analyses. *Early Childhood Education Journal*, *43*(4), 257-267.

Aubrey, C., Dahl, S., & Godfrey, R. (2006). Early mathematics development and later achievement: Further evidence. *Mathematics Education Research Journal*, 18(1), 27–46.

Bachanan, A. (1978). Estimation as an essential mathematical skill. Paper presented at the southwest regional laboratory for educational research and development. Los Alamos, CA.

Ball, D. L. (1993). With an eye on the mathematical horizon: Dilemmas of teaching elementary school mathematics. *Elementary School Journal*, 93, 373–397.

Bargh, J. A., & Schul, Y. (1980). On the cognitive benefits of teaching. *Journal of Educational Psychology*, *72*(5), 593.

Beilock, S. (2011). *Choke: What the secrets of the brain reveal about getting it right when you have to.* New York, NY: Free Press.

Boaler, J. (1997). Reclaiming school mathematics: The girls fight back. *Gender and Education*, *9*(3), 285-305.

Boaler, J. (2015). Fluency without fear: Research evidence on the best ways to learn math facts. Retrieved from *Youcubed.Org*.

Bobis, J. (1991). The effect of instruction on the development of computation estimation strategies. *Mathematics Education Research Journal* , 3, 7-29.

Bobis, J. (1996). Visualization and the development of number sense with kindergarten children. In Mulligan, J. & Mitchelmore, M. (Eds.) *Children's Number Learning* : A Research Monograph of the Mathematics Education Group of Australasia and the Australian Association of Mathematics Teachers. Adelaide: AAMT

Boychuk, T. & Cui, B. (2014). Effects of daily math home practice and number talks on automaticity of basic math facts. *In McDowell foundation for research into teaching.* (Project 238). Retrieved from http://www.mcdowellfoundation.ca/main_mcdowell/.

Bums, M. (1994). "Arithmetic: The last holdout." Phi Delta Kappan, 75(2), 471-477.

Burton, L. L. (2004). *Mathematicians as enquirers: Learning about learning mathematics* (Vol. 34). Springer Science & Business Media.

Calvert, L.M.G. (1999). "A dependence on technology and algorithms or a lack of number sense." Teaching Children Mathematics, 1, 6-7.

Campbell, P. F. (1997). Mathematics for all students: Access, Excellence, and Equity. In J. Trentacosta & M. J. Kenney (Eds.) *Multicultural and gender equity in the mathematics classroom: The gift of diversity.* (pp. 60-70). Reston, VA: The National Council of Teachers of Mathematics, INC

Carpenter, T. P., Franke, M. L., Jacobs, V. R., Fennema, E., & Empson, S. B. (1998). A longitudinal study of invention and understanding in children's multidigit addition and subtraction. *Journal for research in mathematics education*, 3-20.

Carroll, W. M. & Porter, D. (1997). Invented procedures can develop meaningful mathematical procedures. In Chambers, D. L (Ed). *Putting research to practice.* (pp. 16-20). Reston, VA: National Council of Teachers of Mathematics.

Case, R. & Sowder, J. (1990). The development of computational estimation: A neo-Piagetian analysis. *Cognition and Instruction* , 7, 79-104.

Celski, T. (2009). The effect of number talks on student number sense (Thesis). Retrieved from Heritage College.

Chambers, D. L. (1996). Direct modeling and invented procedures: Building on students' informal strategies. *Teaching Children Mathematics*, *3*(2), 92-96.

Chi, M.T.H. (2000). Self-explaining expository texts: The dual processes of generating inferences and repairing mental models In R. Glaser (Ed.), *Advances in instructional psychology: Educational design and cognitive science*. (pp. 161–238). Hillsdale, NJ: Erlbaum

Clements, D. & Battista, M. (1990). Constructivist learning and teaching. The Arithmetic Teacher, 34-35.

Cobb, P. Where is the mind? Constructivist and sociocultural perspectives on mathematical development. *Educational Researcher*, 23, 13-20.

Cobb, P., Wood, T., Yackel, E., Nicholls, J., Wheatley, G., Trigatti, B., & Perlwitz, M., (1991). Assessment of a problem-centered second-grade mathematics project. *Journal for Research in Mathematics Education* , 22, 3-29.

Cobb, P., Yackel, E., & Wood, T. (1993). Chapter 3: Theoretical Orientation. *Journal for Research in Mathematics Education. Monograph, 6*, 21-122.

Creswell, J. W. (2005). *Educational research: Planning, conducting, and evaluating quantitative and qualitative research* (2nd ed.). Upper Saddle River, NJ: Merrill/Prentice Hall.

Croom, L. (1997). Mathematics for all students: Access, Excellence, and Equity. In J. Trentacosta & M. J. Kenney (Eds.) *Multicultural and gender equity in the mathematics classroom: The gift of diversity*. (pp. 1-9). Reston, VA: The National Council of Teachers of Mathematics, INC

Dehaene, S. (2011). *The number sense: How the mind creates mathematics.* New York, NY: Oxford University Press, Inc.

Dewey, J. (1938). *Education and experience.* New York, NY: Collier Books.

Easley, J., Taylor, H. A., & Taylor, J. K. (1990). Dialogue and conceptual splatter in mathematics classes. *The Arithmetic Teacher*, *37*(7), 34.

Ellis, M. W., & Berry III, R. Q. (2005). The Paradigm Shift in Mathematics Education: Explanations and Implications of Reforming Conceptions of Teaching and Learning. *Mathematics Educator*, *15*(1), 7-17.

Feikes, D. & Schwingendorf, K. (2008). The importance of compression in children's learning of mathematics and teacher's learning to teach mathematics. *Mediterranean Journal for Research in Mathematics Education 7*(2).

Flores, A. (1997). Mathematics for all students: Access, Excellence, and Equity. In J. Trentacosta & M. J. Kenney (Eds.) *Multicultural and gender equity in the mathematics classroom: The gift of diversity*. (pp. 81-91). Reston, VA: The National Council of Teachers of Mathematics, INC

Fraenkel, J., Wallen, N., & Hyun, H. (2015). *How to design and evaluate research in education* (9th ed.). New York, NY: McGraw-Hill Education.

Franke, M. L., Kazemi, E., & Battey, D. (2007). Understanding teaching and classroom practice in mathematics. In F. K. Lester (Ed.), Second handbook of research on mathematics teaching and learning (pp. 225-256). Charlotte, NC: Information Age.

Fuson, K. C., Wearne, D., Heibert, J. C., Murray, H. G., Human, P. G., Oliver, A. I., Carpenter, T. P., & Fennema, E. (1997). Children's conceptual structure for multidigit numbers and methods of multi-digit addition and subtraction. *Journal of Research in Math Education,* 28, 130-162.

Gagne, R. M. (1983). Some issues in the psychology of mathematics instruction. *Journal for Research in Mathematics Education*, 14, 7–18.

Gainsburg, J. (2007). The mathematical disposition of structural engineers. *Journal for Research in Mathematics Education*, 477-506.

Garnett, K., & Fleischner, J. E. (1983). Automatization and basic fact performance of normal and learning disabled children. *Learning Disability Quarterly*, 6, 223–230.

Geary, D.C. (1993). Mathematical disabilities: Cognitive, neuropsychological, and genetic components. *Psychological Bulletin*, 114, 345-362.

Geary, D.C., Hoard, M.K., Byrd-Craven, J., Nugent, L., & Numtee, C. (2005). Early identification and intervention for students with mathematics difficulties. *Journal of Learning Disabilities, 38*(4), 324-332.

Geary, D. (2013). Early foundations for mathematics learning and their relations to learning disabilities. *Current Directions in Psychological Science*, 22(1), 23–27.

Gersten, R., & Chard, D. (1999). Number sense: Rethinking arithmetic instruction for students with mathematical disabilities. *Journal Of Special Education*, *33*(1), 18.

Gersten, R., Jordan, N. C., & Flojo, J. R. (2005). Early identification and intervention for students with mathematics difficulties. *Journal of Learning Disabilities*, 38, 293-304.

Gray, E. M. & Tall, D. O. (1994). Duality, ambiguity, and flexibility: A "proceptual" view of simple arithmetic. *Journal for research in Mathematics Education*, 116-140.

Greeno, J. (1991). Number sense as situated knowing in a conceptual domain. *Journal for Research in Mathematics Education*, *22(*3), 170-218. Retrieved from http://www.jstor.org/stable/749074 doi:1

Griffin, C. C., League, M. B., Griffin, V. L., & Bae, J. (2013). Discourse Practices in Inclusive Elementary Mathematics Classrooms. *Learning Disability Quarterly*,*36*(1), 9-20.

Griffin, S. (2004). Teaching number sense. *Educational Leadership, 61*(5), 39-42.

Griffin, S. A., Case, R., & Siegler, R. S. (1994). Rightstart: Providing the central conceptual prerequisites for first formal learning of arithmetic to students at risk for school failure. In K. McGilly (Ed.), *Classroom lessons: Integrating cognitive theory and classroom practice* (pp. 25-49). Cambridge, MA: MIT Press.

Gurganus, S. (2004). Promote number sense. Intervention in School and Clinic, 40(1), 55-58.

Hiebert, J., & Lefevre, P. (1986). Conceptual and procedural knowledge in mathematics: An introductory analysis. *Conceptual and procedural knowledge: The case of mathematics*, *2*, 1-27.

Hiebert, J., & Wearne, D. (1993). Instructional Tasks, Classroom Discourse, and Students' Learning in Second-Grade Arithmetic. *American Educational Research Journal*, *30*(2), 393-425.

Hope, J. & Sherril, J. (1987). Characteristics of unskilled and skilled mental calculators. *Journal for Research in Mathematics Education* , 18, 98-111.

Hope, J., & Small, M. (1994). Number sense in interactions. Program Information, 4, 18-19. Toronto, Ontario: Ginn Publishing Canada Inc..

Huberty, C. J., Dresden, J., & Bak, B. G. (1993). Relations among dimensions of statistical knowledge. *Educational and Psychological Measurement*, *53*(2), 523-532.

Humphreys, C. & Parker, R. (2015). *Making number talks matter.* Portland, ME: Stenhouse Publishing.

Jones, Vinetta. (1993). *Views on the state of public schools.* Paper presented at the conference on the State of American Public Education.

Jordan, N. & Dyson, N. (2014). *Number sense interventions.* Baltimore, MA: Brookes Publishing.

Jordan, N. C., Glutting, J., & Ramineni, C. (2010). The importance of number sense to mathematics achievement in first and third grades. *Learning & Individual Differences*, *20*(2), 82-88.

Kilpatrick, J., Swafford, J., & Findell, B. (2001). Adding it up: Helping children learn mathematics. *The National Academies Press. 2*(4), 04.

Lampert, M. (1990). When the problem is not the question and the solution is not the answer: Mathematical knowing and teaching. *American educational research journal*, *27*(1), 29-63.

Malloy, C. E. (1997). Including African American students in the mathematics community. In J. Trentacosta & M. J. Kenney (Eds.) *Multicultural and gender equity in the mathematics classroom: The gift of diversity.* (pp. 23-33). Reston, VA: The National Council of Teachers of Mathematics, INC.

McClain, K., & Cobb, P. (2001). An analysis of development of sociomathematical norms in one first-grade classroom. *Journal for research in mathematics education*, 236-266.

McCloskey, M., & Macaruso, P. (1995). Representing and using numerical information. American Psychologist, 50, 351-363.

McIntosh, A., Reys, B., & Reys, R. (1992). A proposed framework for examining basic number sense. *For the Learning of Mathematics*, *12*(3), 2-44.

McMillan, J. H. (2004). *Educational research: Fundamentals for the consumer* (4th ed.). Boston: Allyn & Bacon.

Melhuish, E. C., Sylva, K., Sammons, P., Siraj-Blatchford, I., Taggart, B., Phan, M., & Malin, A. (2008). Preschool influences on mathematics achievement. *Science*, 321, 1161–1162.

Mertler, C. A. (2014). *Action research: Improving schools and empowering educators.* (4th ed.). Thousand Oaks, CA: Sage Publications, Inc.

Mills, G. E. (2011). *Action research: A guide for the teacher researcher* (4th ed.). Boston, MA: Pearson.

National Center for Education Statistics. (2016). 2015 Mathematics and Reading Assessments. In The nation’s report card. Retrieved from http://www.nationsreportcard.gov/reading_math_2015/#?grade=4

National council of teachers of mathematics. (1989). *Curriculum and Evaluation of Standards for School Mathematics.* Reston, VA: National Council of Teachers of Mathematics.

National Council of Teachers of Mathematics. (1991). Professional standardsfor teaching mathematics. Reston, VA: Author

National Council of Teachers of Mathematics (1995). *Assessment Standards for School Mathematics.* Reston, VA: National Council of Teachers of Mathematics.

National Council of Teachers of Mathematics (2000). *The principles and standards for school mathematics. Reston*, VA: National Council of Teachers of Mathematics.

National Governors Association Center for Best Practices & Council of Chief State School Officers. (2010). What parents should know. In *Common Core State Standards Initiative.* Retrieved from http://www.corestandards.org/what-parents-should-know/

National Research Council. (2001). *Adding it up: Helping children learn mathematics.* J. Kilpatrick, J. Swafford, & B. Findell (Eds). Mathematics Learning Study Committee, Center for Education, Division of Behavioral and SOcial Sciences and Education. Washington, D.C.: National Academy Press.

Norasmah, O. I. & Chia, S. P. (2016). The challenges of action research implementation in malaysian schools. *Pertanika Journal of Social Sciences & Humanities,* 24(1), 43-52.

Northwest Evaluation Association. (2017). MAP growth. In *NWEA measuring what matters* (Growth over time). Retrieved from https://www.nwea.org/content/uploads/2017/05/MAP-Growth-Fact-Sheet.pdf

Oakes, J. (1985). *Keeping track: How schools structure inequality.* New Haven, Conn.: Yale University Press.

Oakes, J. (1990). Opportunities, achievement, and choice: Women and minority students in science and mathematics. *Review of Research in Education.* 16, 153-222.

Oakes, J. (1986). Tracking, inequality, and the rhetoric of reform: Why schools don't change. *Journal of Education.* 168, 60-78.

O'Connell, S., & SanGiovanni, J. (2011). *Mastering the basic math facts in multiplication and division.* Portsmouth, NH: Heinemann.

O'Nan, M. (2000). Daily number talks and the development of computational strategies in third graders. (Masters Thesis). Retrieved from ERIC.

Okamoto, Y. (2015). *The implementation process and impact of a six-week number talks intervention with sixth-grade middle school students in a large urban school district*. ProQuest Dissertations & Theses Global. Retrieved from https://login.pallas2.tcl.sc.edu/login?url=http://search.proquest.com/docview/1691345397?accountid=13965

Parrish, S. (2010). *Number talks: Helping children build mental math and computation strategies, grades K-5*. Math Solutions.

Parrish, S. (2011). Number talks build numerical reasoning. *Teaching Children's Mathematics 18*(3), 198-206.

Parsons, S., & Bunner, J. (2005). *Does numeracy matter anymore?* London, UK: National Research and Development Centre for Adult Literacy and Numeracy.

Powell, K. C., & Kalina, C. J. (2009). Cognitive and social constructivism: Developing tools for an effective classroom. *Education*, *130*(2), 241-250.

Presmeg, N. (1986). Visualization in high school mathematics. *For the Learning of Mathematics*, 6 (3), 42-46.

RAND Mathematics Study Panel & Ball, D. L. (2003). *Mathematical proficiency for all students: Toward a strategic research and development program in mathematics education*. Rand Corporation.

Reyes, B. (1985). Mental computation. *Arithmetic Teacher*. 32, 43-46.

Reys, B. (1994). Promoting number sense in the middle grades. Mathematics Teaching in the Middle School, 1(3), 114-120.

Reys, B. & Reys, R. E., (1986). One point of view: Mental and computational estimation - their time has come. *Arithmetic Teacher*. 33, 4-5.

Russell, S. J. (2000). Developing computational fluency with whole numbers. *Teaching Children Mathematics*, 7 (3): 154–58.

Ruter, K. (2015). Improving number sense using number talks (Thesis). Retrieved from Digital Collects at Dordt.

Schmuck, R. A. (1997). *Practical action research for change*. Arlington Heights, IL: Skylight Professional Development.

Schoenfeld, A. H. (1992). Learning to think mathematically: Problem solving, metacognition, and sense making in mathematics. *Handbook of research on mathematics teaching and learning*, *334370*.

Schoenfeld, A.H. (2007). What is mathematical proficiency and how can it be assessed?. *Assessing mathematical proficiency*, 52, 59.

Siegler, R. S. (2003). Implications of cognitive science research for mathematics education. *A research companion to principles and standards for school mathematics*, 219-233.

Siegler, R.S., 1988. Strategy choice procedures and the development of multiplication skill. *Journal of Experimental Psychology*. 117, 258 – 275.

Silver, E. A., & Stein, M. K. (1996). The QUASAR project: the "revolution of the possible" in mathematics instructional reform in urban middle schools. Urban Education, 30(4), 476-521.

Son, J. (1992). Doing and construing mathematics in screen space, In Perry, B., Southwell, B., & Owens, K. (Eds.). *Proceedings of the Thirteenth Annual Conference of the Mathematics Education Research Group of Australasia* . Nepean, Sydney: MERGA.

Sood, S., & Jitendra, A. K. (2007). A comparative analysis of number sense instruction in reform-based and traditional mathematics textbooks. *Journal of Special Education, 41*(3), 145-157.

South Carolina Department of Education. (2016). South carolina state report card. *South Carolina department of education.* Retrieved from http://ed.sc.gov/assets/reportCards/2015/elem/c/e4002101.pdf

Sowder, J. (1992). Making sense of numbers in school mathematics. In G. Leinhardt, & R. Hattrup (Eds.), Analysis of arithmetic for mathematics teaching (pp. 1-51). Hillsdale, N. J.: Erlbaum.

Sparks, S.D. (2013). Students can learn by explaining, studies say. Retrieved from http://www.edweek.org/ew/articles/2013/05/31/33aps.h32.html

Spring, J. (2014). *The American school: A global context.* (9th ed.). New York, NY: McGraw-Hill Education.

Starkey, P., Klein, A., & Wakeley, A. (2004). Enhancing young children's mathematical knowledge through a pre-kindergarten mathematics intervention. *Early Childhood Research Quarterly*, 19(1), 99–120.

Stein, M. K., Engle, R. A., Smith, M. S., & Hughes, E. K. (2008). Orchestrating productive mathematical discussions: Five practices for helping teachers move beyond show and tell. *Mathematical Thinking & Learning*, *10*(4), 313-340.

Stott, D., & Graves, M. (2015). Adapting number talks to foreground mathematical progression in South African classrooms. In J. Novotná & H. Moraová (Eds.), Developing mathematical language and reasoning - International Symposium Elementary Math Teaching (pp. 311–321).

Suzzallo, H. (1912). The teaching of primary arithmetic; a critical study of recent tendencies in method. Boston: Houghton Mifflin

Thompson, G. W. (1991). *The effect of systematic instruction in mental computation upon third grade students' arithmetic problem-solving and computation ability*(Order No. 9131500). Available from ProQuest Dissertations & Theses Global. (303925839). Retrieved from https://login.pallas2.tcl.sc.edu/login?url=http://search.proquest.com/docview/303925839?accountid=13965

Toll, M., Kroesbergen, E. H. & Van Luit, J. H. (2016). Visual walking memory and number sense: Testing the double deficit hypothesis in mathematics. *British Journal of Educational Psychology*. 86(3), 429-445.

Tournaki, N. (2003). The differential effects of teaching addition through strategy instruction versus drill and practice to students with and without learning disabilities. *Journal Of Learning Disabilities*, *36*(5), 449-458.

Trafton, P. (1992). Using number sense to develop mental computation and computational estimation. In C. Irons (Ed.) *Challenging Children to Think when they Compute* . (pp. 78-92). Brisbane: Centre for Mathematics and Science Education, Queensland University of Technology.

Tsao, Y. L. (2004). Exploring the Connections among number sense, mental computation performance, and the written computation performance of elementary preservice school teachers. *Journal of College Teaching & Learning*, *1*(12), 71-90.

Tsao, Y. L., & Lin, Y. C. (2012). Elementary school teachers' understanding towards the related knowledge of number sense. *US-China Education Review,* (2012), 17-30.

Walshaw, M., & Anthony, G. (2008). The teacher's role in classroom discourse: A review of recent research into mathematics classrooms. *Review of Educational Research*, 78, 516–551.

Walker, E. L. & McCoy, L. P. (1997). Mathematics for all students: Access, Excellence, and Equity. In J. Trentacosta & M. J. Kenney (Eds.) *Multicultural and gender equity in the mathematics classroom: The gift of diversity*. (pp. 1-9). Reston, VA: The National Council of Teachers of Mathematics, INC

Watson, K. & Young, B. (1986). Discourse for learning in the classroom. Language Arts, 63,126-133.

Webb, N. M., Franke, M. L., Ing, M., Wong, J., Fernandez, C.H., Shin, N., & Turrou, A. C. (2014). Engaging with others' mathematical ideas: Interrelationships among student participation, teachers' instructional practices, and learning. *International Journal of Educational Research,* 63, 79-93.

White, D. Y. (2003). Promoting productive mathematical classroom discourse with diverse students. *Journal of Mathematical Behavior*, 22, 37–53.

Wittrock, M. C. (1990). Generative processes of comprehension. Educational Psychologist, 24, 345-376.

Thornton, C. A. & Tucker, S. C. (1989). Lesson Planning: The Key to Developing Number Sense. Arithmetic Teacher, 36 (2), 18–21.

Tsao, Y. L., & Lin, Y. C. (2011). The study of number sense and teaching practice. *Journal of Case Studies in Education*, *2*, 1.

Vygotsky, L. S. (1978). Mind in society: The development of higher mental process.

Yang, D. C. (2001). Developing number sense. *Australian Primary Mathematics Classroom*, 6(3), 20-25.

Yang, D. C. (2002). Teaching and Learning Number Sense: One Successful Process-Oriented Activity With Sixth Grade Students in Taiwan. *School Science and Mathematics*, *102*(3), 1-6.

Yang, D. C. (2003). Teaching and learning number sense–an intervention study of fifth grade students in Taiwan. *International Journal of Science and Mathematics Education*, *1*(1), 115-134.

APPENDIX A: NUMBER SENSE PRETEST

Pretest

Directions: Solve each problem below. Use numbers, pictures, and/or words to show how you got your answer.

<table>
<tr><td colspan="2">1. The friends in your class like to give each other candy. You decide to give each classmate 3 pieces of candy. You have 19 classmates. How many pieces of candy will you need? Show how you solved this problem.</td></tr>
<tr><td colspan="2">2. Mrs. Hidalgo bought 48 flags for her neighbors. She gives 8 flags to each neighbor. How many neighbors does she have?</td></tr>
<tr><td>Directions: Fill in the blanks with the correct numbers to solve the problem.

3. 8 × 6 = (5 + _______) × 6
= (5 × 6) + (_______ × 6)
= 30 + _______
= _______</td><td>4. 436 + 234 = ________</td></tr>
<tr><td>5. 45 ÷ 9 = _______</td><td>6. 4 x 60 = ______</td></tr>
<tr><td colspan="2">7. Use estimation to solve the problem. James receives 5 dollars for each can or box of food he delivers to the homeless shelter. He brings 48 cans and 32 boxes to the shelter. About how much money does he earn?</td></tr>
<tr><td>8. 44 + 36 = ________</td><td>9. 363 - 129 = _______</td></tr>
<tr><td>10. 59 - 49 = _______</td><td></td></tr>
</table>

APPENDIX B: NUMBER SENSE POSTTEST

Posttest

Directions: Solve each problem below. Use numbers, pictures, and/or words to show how you got your answer.

<table>
<tr><td colspan="2">1. 6 friends decided to make dinner together. Each person needs 2 potatoes, 3 carrots and 5 chunks of meat. How many potatoes, carrots, and chunks of meat will they need in all.

____ potatoes ____ carrots ____ chunks of meat</td></tr>
<tr><td colspan="2">2. Susan has 63 pieces of chocolate. She gives 7 pieces of chocolate to each of her friends. How many friends can she share her chocolate with? Show your work.</td></tr>
<tr><td>Directions: Fill in the blanks with the correct numbers to solve the problem.

3. 9 × 8 = (5 + _______) × 8
= (5 × 8) + (_______ × 8)
= 40 + _______
= _______</td><td>4. Solve the equation below. Choose TWO correct answers.

4 × (7 - 2) = ____________

A) 26
B) 20
C) 25 - 5
D) 15 + 10</td></tr>
<tr><td>5. 27 ÷ 3 = _______</td><td>6. 6 x 20 = ______</td></tr>
<tr><td colspan="2">7. Use estimation to solve. Morgan earns $9 an hour working at a bookstore. She works for 64 hours the first week and 48 hours the second week. About how much does Morgan earn each week?</td></tr>
<tr><td>8. 81 + 27 = _____</td><td>9. 564 - 139 = _______</td></tr>
<tr><td>10. 84 - 61 = ____</td><td></td></tr>
</table>

APPENDIX C: SEMI-STRUCTURED GROUP INTERVIEW QUESTIONS

The following group of questions was used as an outline for the semi-structured group interviews.

1. What are your feelings about mathematics and why?
2. What is your opinion about number talks?
3. If you had the choice, would you choose to continue to complete number talks in your mathematics class? Why or why not?
4. If you could change something about number talks, what would it be? Why?

APPENDIX D: PARENTAL CONSENT FORM

(adapted from Mertler, 2014)

Parental Consent Form

Dear: [Guardian]

My name is Nicole Gaillard. I am a student at the University of South Carolina. I am conducting a research study to examine how the use of number talks incorporated into the mathematics classroom to improve number sense in students could have an impact on my students' academic achievement in their third-grade mathematics class. I plan to collect data from my third-grade math students and am asking for your child's participation in this research.

You child's participation will involve mathematics mini lessons incorporated into their regular math class and completion of a pretest and posttest during the research study.

These tests' data will help me to evaluate strategies that may help your child to achieve more in their mathematics course.

If you or your child chooses not to participate, there will be no penalty. It will not affect your child's grade, treatment, services rendered, and so forth, to which you or your child may otherwise be entitled. Your child's participation is voluntary, and he/she is free to withdraw from participation at any time without suffering any ramifications. The results of the research study may be published, but your child's name will not be used. Data collected will be kept confidential and will not be shared with anyone. I will destroy all data within one year of completing the study.

If you have any questions concerning this study or your child's participation in this study, please feel free to contact me at 803-281-0348 or gaillan@email.sc.edu.

Sincerely,

Nicole Gaillard

By signing below, I give consent for my child to participate in the above-referenced study.

Parent's Name: ___________________ Child's Name: _______________

Parent's Signature: ______________________

By signing below, I **DO NOT** give consent for my child to participate in the above-referenced study.

Parent's Name: ____________________ Child's Name: ______________

Parent's Signature: ___________________________________

APPENDIX E: ASSENT FORM

(adapted from Mertler, 2014)

Assent Form

Dear: [Student]

My name is Nicole Gaillard. I am a student at the University of South Carolina. I am conducting a research study to examine how the use of number talks during our mathematics class to improve number sense in students could have an impact on your academic achievement in your third-grade math class. I plan to collect data from you and am asking for your participation in this research.

Your participation will involve participating in mathematics mini lessons incorporated into your regular math class and completion of a pretest and posttest during the research study.

These tests data will help me to evaluate strategies that may help you to achieve more in your mathematics course.

If you choose not to participate, no one will be angry with you, and there will be no punishment. It will not affect your grade or treatment in this class. Your participation is voluntary, which means that you can change your mind and stop participating at any time. Your name will not be anywhere on your tests. Finally, I will destroy your tests within one year of completing the study.

If you have any questions about this study, please feel free to contact me at 803-281-0348 or gaillan@email.sc.edu.

Sincerely,
Nicole Gaillard

Please check one of the following:

___**YES.** I want to be in the study. I understand the study will be done during class time. I understand that, even if I check "yes" now, I can change my mind later.

___**NO.** I do not want to be in the study.

Your Name: ____________________ Signature: _______________